The Journal of

THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Registered at the G.P.O., Sydney, for transmission by post as a periodical.

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VOL. 3, No. 4 DECEMBER, 1937

Technical Literature and the Investigator

Agricultural scientists, and indeed all workers in science, are daily confronted with the impossibility of keeping abreast of the rapid advances which are proceeding in their particular spheres of study. The enormous output in the form of technical articles and research bulletins has created a situation which is no less embarrassing than terrifying to those who would claim more than a mere acquaintance with the progress in specialized fields. The position, admittedly, is relieved to some extent by the abstracting periodicals—particularly those journals which aim at giving a substantial summary of the important contributions published *in extenso* in the literature of various countries. Nevertheless, there still remains the necessity for close perusal and study of the original documents in many instances, if the full value of a contribution is to be appreciated. Pressure of time in the midst of a heavy research programme not only may lead to inability on the part of the

investigator to cope with the literature output, but sometimes results in a certain unwitting disinclination to regard the publications of his co-workers as anything much more than the embodiment of so much scientific paraphernalia. There is no doubt that very many of the contributions now being published could well be stripped of much of their tabulated and graphic data, not to mention the need for avoiding prolixity in the narrative of experimental procedure and discussion of results. All too often, authors aim at recounting the most minute details of every phase of an investigation, resulting in a cluttering of the literature with matter which could be presented much more briefly and pointedly. In an age when the day of twenty-four hours is all too short for those engaged in scientific research, there is much to be said against the attitude of some writers who assess the extent of their contributions to knowledge by the numbers of pages, graphs and tables contained in their several publications.

Another regrettable feature of present-day specialism is the difficulty that almost every specialist finds in securing some acquaintance with the general trend of advances taking place in other branches of science. The number of workers who are disposed to contribute articles of a review nature is unfortunately very small, and once a writer has expounded in a detailed technical article the aims, methods and results of a particular investigation, there is rarely displayed any tendency to review the entire position in that certain branch of study for the general information of workers in other sciences. Many an idea and inspiration has resulted from a stimulating account of the present position in various fields of scientific inquiry, and much is to be said in favour of the publication of short semi-technical articles of *review* character, quite apart from the more detailed expositions on special investigations for research journals. Not a great many publications cater for this class of contribution, but those that do are fulfilling a function of some consequence at a time when the dangers of over-specialization are plainly apparent. The graduand in agricultural science probably has a wider appreciation of the general trend of scientific developments in agriculture than the average graduate of 10 or 15 years' standing who has devoted his energies to the pursuit of knowledge in one single field. There are times when the mind of every worker in science needs re-equipping and re-orientating, and the intellectual refreshment to be obtained from contact with current developments in agricultural science and science generally is not without a highly cultural value also. Breadth of knowledge counts for so much in all walks of life, and the more capacious one's outlook and the wider the grasp of current developments, the more effectively can the agricultural investigator discharge his responsibilities in his chosen sphere. Not of small importance, also, is the manner in which all this can

strengthen the approach of the scientist to the needs of the practical agriculturist ; and if the value of agricultural research is to be measured in terms of the ready adoption of improved practices, this may be said to depend in no small degree on the understanding and sympathy of the primary producer towards what science is attempting to achieve for him.

The Air Nitrogen Industry*

ITS CONTRIBUTION TO THE RANGE OF NITROGENOUS FERTILIZERS.

By

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Few developments can have been more spectacular in their progress than the commercial fixation of atmospheric nitrogen.

Prior to 1900, little success, beyond that of Cavendish, who in 1781 had combined traces of nitrogen and oxygen by means of an electric spark, had been achieved. The 20th century, however, opened with the first commercially successful plant to bring about this most important combination. The success of Bradley and Lovejoy in 1902 and, a year later, that of Birkeland and Eyde in Norway, gave rise to what is known as the arc process. By this method about 1·2 per cent. of the air passing through an electric arc at a temperature of 3,300° C., is changed to nitric oxide. The power required for the purpose, namely 61,000 K. watt hours per ton of nitrogen fixed, confines the successful operation of this process to places where power is exceptionally cheap. Such a place is Norway, with its reserves of water power, and today the utilization of this process is centred almost solely in one large concern there—the Norsk-Hydro. Further, the output of the process is limited to nitrates. The works of the Norsk-Hydro have a capacity of 90,000 metric tons of nitrogen per annum, but actually they produce today no more than a few thousand tons. Other arc processes exist in Germany, France and Switzerland.

THE CYANAMIDE PROCESS.

This process, arising from the work of Frank and Caro in Germany, was first put into successful commercial operation at the Niagara Falls in 1909.

* Address to the N.S.W. Branch of the Institute on August 13, 1937.

The reactions involved are as follow:

$$CaCO_3 \rightarrow CaO + CO_2 \quad \text{at } 1100^\circ \text{ C.}$$

$$CaO + 3C = CaC_2 + CO \quad \text{at } 2200^\circ \text{ C.}$$

and $$CaC_2 + N_2 = CaCN_2 + C \quad \text{at } 1000^\circ \text{ C.}$$

Total power required, 12,000 to 14,000 K. watt hours per ton of nitrogen fixed.

In addition to the power required, cyanamide itself has not achieved marked success as a fertilizer. It is disagreeable to handle, causes reversion when mixed with superphosphate, and has an inherent toxicity to plants in dry seasons.

For these reasons, its production has remained practically stationary at a little over 200,000 tons of nitrogen fixed, since 1917. Germany is now the largest producing country (121,000 tons of nitrogen), then follow Japan, Canada and Italy.

THE AMMONIA SYNTHESIS.

The successful commercial fixation of nitrogen on a triumphant scale will no doubt always be associated with the German chemist, Haber, and his co-working engineer, Bosch. In 1905, Haber and Le Rossignol published investigations of the ammonia equilibrium:

$$N_2 + 3H_2 \rightleftarrows 2NH_3$$

which appeared sufficient to arouse commercial interest. Introducing catalysts (iron and nickel) and pressure to help in promoting the combination, Haber succeeded in obtaining a yield which he gave as 0·012 per cent. of NH_3 at 1000° C.

In 1906–07, Nernst and Jost attracted further attention to this matter. Jost worked at what was considered then a very high pressure, namely 74·5 atmospheres. At this stage, however, commercial success still appeared hopeless. In 1908, Haber joind hands with Bosch, and both were assisted by a large and famous German dye and chemical corporation, known then as the Badische Anilin und Soda Fabrik. Success followed these efforts, and in 1911 the first technical plant, erected at Oppau, produced ammonia equivalent to about 56 pounds of nitrogen per day. Developments thereafter were extraordinarily rapid, and in 1913 this plant was increased to a size capable of fixing 30 tons of nitrogen daily.

Work at higher pressures and with improved catalysts had solved the problem.

The movement of the ammonia equilibrium to the right is accompanied by an emission of considerable heat—12,000 gramme-calories per mol. NH_3—and a contraction of volume. Therefore, according to Boyle's Law, the desirable combination is directly proportional to the pressure, and inversely proportional to the temperature. Definite limitations to the lowering of temperature, however, are set by the catalysts which require some 400–500° C. for optimum efficiency.

Haber and Bosch therefore were faced with two major problems :

(1) A catalyst was desired that would be as highly active at as low a temperature as possible.

(2) Containers had to be designed that would withstand a pressure of at least 200 atmospheres.

A third problem was presented by the hydrogen. On account of the sensitivity of catalysts to poisoning by certain impurities, both of the reacting gases had to be supplied in as pure a state as possible. The nitrogen obtained by the liquefaction and fractional distillation of air presented no great difficulties. Hydrogen, to be obtained from water, however, proved difficult and very costly. Actually about 50 per cent. of the total cost of the synthesis of ammonia is due to the preparation of this ingredient.

Space does not permit of details in regard to the overcoming of these and many other obstacles to the chemical engineer. Herein, of course, lies to a large extent the monumental work of these men.

The Haber-Bosch process now deals with these problems somewhat as follows :

The process operates at 500° C. and 200 atmospheres pressure.

The " catalytic mass " probably consists of 98 per cent. of iron plus 1 per cent. each of the difficultly reducible oxides, potash and alumina. It suffers chiefly from overheating and poisoning, and twelve months is considered a long life.

The " bomb ", as the catalytic chamber is called, is made of a steel possibly containing tungsten, nickel and a small amount of carbon. Such a steel resists, in a high degree, the destructive action of hydrogen.

The Reaction Chamber.

Up to date information, in detail, on such a key unit of the fixation process is naturally difficult, if not impossible, to obtain. The following brief description of a probable Haber converter, reaction chamber or bomb is taken from Curtis's " Fixed Nitrogen " :

> The outer shell consists of forgings of tungsten steel, each 19 ft. 7 inches long, 3 ft. 9 inches outside diameter, and walls 7 inches thick, and held in position by bolts, each 4 inches in diameter. Fitting closely inside this outer shell is a soft steel liner about 1 inch thick, which shields it from any exposure to hot gases. Between this liner and another similar one, is an annular space of about 1 inch into which is pumped nitrogen, possibly at a pressure equal to that inside the conversion tube itself. The second steel liner surrounds a cylinder of 2½ inches of heat-insulating brick, which itself encircles a steel cylinder containing the catalytic mass. The entire bomb is well lagged by an external heat lagging, spaced a small distance from the outside of the converter, so as to permit the cooling of the outside shell by a current of air.

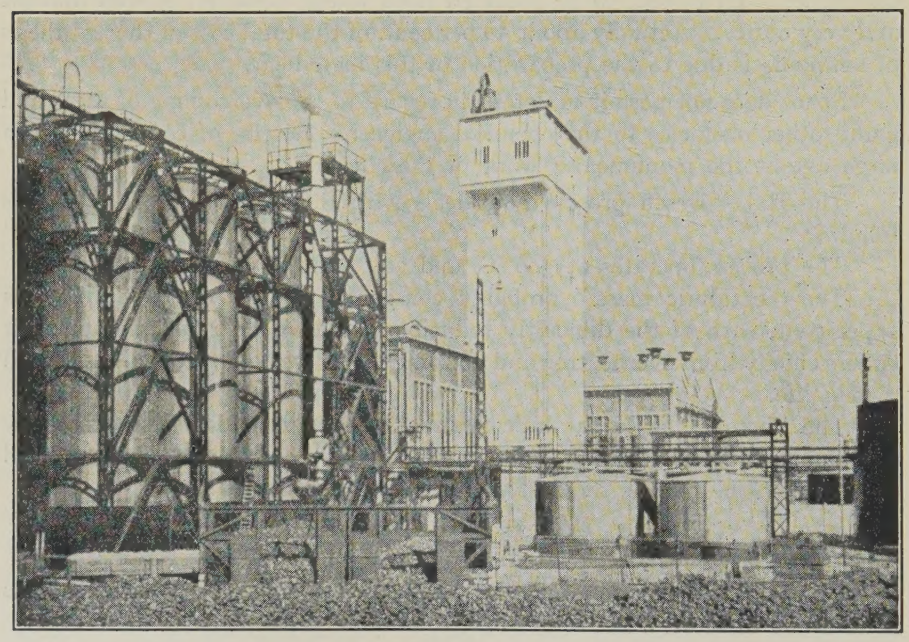
The Hydrogen and Nitrogen.

Water gas, formed by partly quenching glowing coke, consists chiefly of hydrogen and carbon monoxide with a little nitrogen, carbon dioxide and other

soluble impurities. Producer gas, formed when the partly quenched coke is revived by air, contains chiefly nitrogen with smaller amounts of carbon monoxide and hydrogen.

From a mixture of approximately two volumes of water gas and one volume of producer gas, the soluble constituents are washed out, whilst the remaining gases, hydrogen, nitrogen and carbon monoxide are mixed with steam and passed over a catalyst (usually iron oxide) at a temperature of 500° C., when the following reaction proceeds almost completely to the right :

$$CO+H_2O \rightleftarrows CO_2+H_2.$$



A Granulation Tower. (*After Bernard.*)

The CO_2 is then washed out, and the last traces of CO removed by scrubbing with cuprous ammonium formate.

Any shortage of nitrogen is then made up by adding some obtained by the fractional distillation of liquid air.

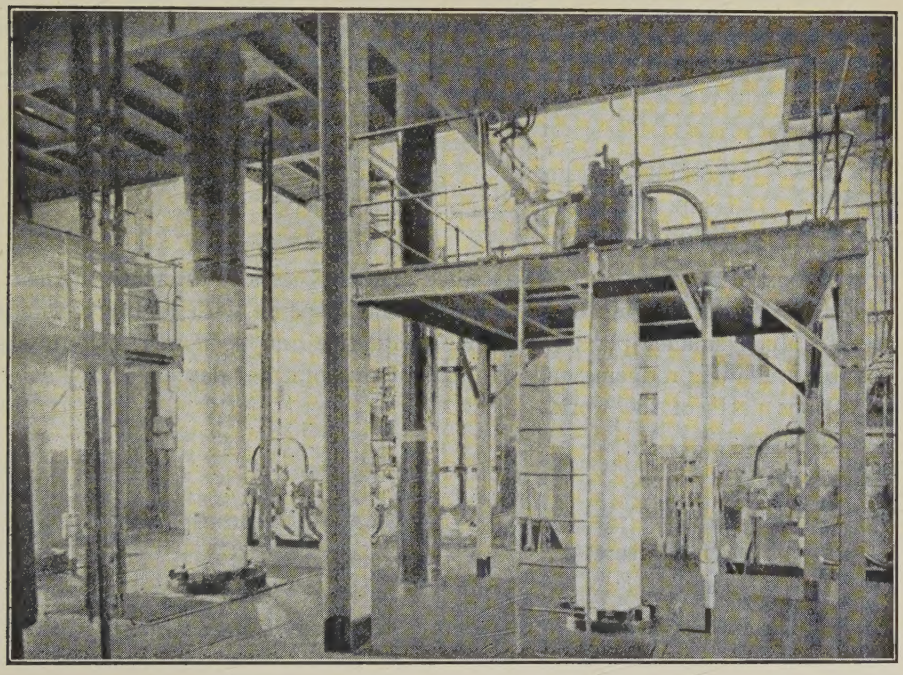
The yield of ammonia obtained by the Haber-Bosch process is about 12 per cent.

The power required is about 4,000 K. watt hours per ton of nitrogen fixed.

The capacity in 1928 of the two huge works in Germany is described in a publication issued by the I. G. Farbenindustrie Aktiengesellschaft as follows :

" The plant at Oppau, about 1¼ miles north of Ludwigshafen, is now producing about 100,000 tons of fixed nitrogen per annum. The Leuna Works, erected between Merseburg

and Corbetha, near the village of Leuna, has now an annual production capacity of about 500,000 tons of fixed nitrogen. Both plants together, therefore, caa fix about 600,000 tons of nitrogen every year. To transport this quantity of fixed nitrogen in the form of sulphate of ammonia would require approximately 200,000 goods-waggons of 15 tons each which would make a single train about 1,116 miles long. The abovementioned annual output corresponds to a production of 209 lbs. of fertilizer per second, involving the combination of about 586 cubic feet of nitrogen with three times this volume of hydrogen. That at Oppau covers an area of about 494 acres, and the Leuna Works about 1,482 acres. Each factory comprises a group of 400–600 buildings of which the chief manufacturing units and stores (silos) attract the most attention. Both works have their own railway yards, with tracks of standard gauge and a total length of about 158 miles."



A Reaction Tube (Casale). *(After Bernard.)*

MODIFICATIONS OF THE HABER-BOSCH PROCESS.

Referring back to the application of Boyle's law to the ammonia equilibrium, and having regard to the numerous substances likely to behave satisfactorily as catalysts, one can easily imagine how modifications of the Haber-Bosch process might arise. The following brief descriptions of the other commercial methods of synthesizing ammonia will illustrate these considerations.

The Claude Process.

Working pressure	1,000 atmospheres
Temperature	500° C.
Yield	From 25 to 57 per cent.

The yield per unit weight of catalyst in unit time is much higher than that from the Haber process. Therefore, much more heat is generated and its dissipation becomes a paramount problem. The life of the catalyst, too, is much shorter.

Instead of the conversion taking place in one large converter, as in the Haber process, a number of smaller converters arranged in series are used. These smaller converters are designed to dissipate the heat more rapidly.

This process introduces a different method of obtaining pure hydrogen. Coke oven gas is progressively liquefied until only the hydrogen, which liquefies at a lower temperature than any of the other ingredients, remains.

The Casale Process.

Working pressure	About 800 atmospheres
Temperature	550°–600° C.
Yield	15 per cent.

Elaborate means have been designed in this process to dissipate the heat, and thus prolong the life of the catalyst and dispense with highly resistant steels. Much smaller plants, both in actual size and economic output, are possible. Plants producing only five tons of ammonia per day are in operation in various parts of the world.

Fauser Process.

Working pressure	200–300 atmospheres.
Temperature	450°–600° C.
Yield	12 per cent.

Similar in design and working details to those of Haber-Bosch.

Mont Cenis Process.

Working pressure	100 atmospheres
Temperature	400° C.
Yield	12–13 per cent.

In this process, the chief modification appears to be due to the catalyst which permits of a Haber-Bosch yield at half the pressure.

Other processes include an American method known as the "N.E.C." and a Japanese, the Shibita process.

Particulars in regard to the numbers of factories operating these various processes, together with their capacities, are shown in Table 1.

An idea of the present (1932–33) distribution of installed nitrogen capacity (synthetic ammonia) in various countries is given in Table 2.

TABLE 1.—*World Capacity of Synthetic Ammonia Plants.*

Process.	Number of Plants.	Capacity 1932–33 Metric Tons of Nitrogen.	Percentage.
Haber-Bosch	9	1,507,809	53
Casale	26	441,445	16
Fauser	15	304,600	11
Claude	20	226,136	8
N.E.C.	14	134,210	5
Mont Cenis	9	191,610	6
Japanese (Showa Hiryo)	1	30,000	1
Totals	94	2,835,810	100
Hydrogen Basis (Waeser's figures)—			
Water gas		1,340,600	52·4
Coke oven gas		746,200	29·1
Electrolytic		435,400	17·0
By-product		26,600	1·0
Natural gas		12,000	0·5
Totals		2,560,800	100·0

TABLE 2.—*Installed Nitrogen Capacity (Synthetic Ammonia) by Various Countries.*

Country.	1,000 Million Tons of Nitrogen.	Percentage of World.	Country.	1,000 Million Tons of Nitrogen.	Percentage of World.
Germany	1,238	44	Poland	51	2
U.K.	236	8	Russia	67	2
U.S.A.	236	8	Manchuria	36	1
Belgium	220	8	Canada	21	
France	203	7	Switzerland	15	
Japan	192	7	Czechoslovakia	12	2
Netherlands	125	4	Spain	8	
Norway	98	4	Sweden	3	
Italy	76	3			

INFLUENCE OF FIXATION UPON WORLD CONSUMPTION OF NITROGEN.

If the successful commercial fixation of nitrogen in 1913 was a factor in "prolonging the agony" of the Great War—and of course it undoubtedly was—it at least made some amends by lightening the post-war burden. A study of the consumption figures for nitrogen as revealed in Table 3, taken in

conjunction with other considerations, reveals this fact. During the decade immediately preceding the war, the use of nitrogen for agriculture in the world was on the increase. This was of course checked by the war. Farm lands in Europe dropped back in productivity largely on account of the inability to obtain fertilizers and nitrogen in particular, and food supplies became very short—in Western Europe, nitrogen is an essential for satisfactory cereal production.

Immediately after the war, one of the first considerations was that of restoring farming to at least its pre-war rate of productivity. The figures show, however, that the demand for nitrogen continued as though the pre-war development had never been interrupted, and when at last in 1924 it became possible for supply to meet demand the latter had reached a figure of 1·2 million tons of nitrogen, or an increase over that of 1913 of half a million tons. In 1929–30, consumption reached the two million mark. The 700,000 tons of 1913 had been supplied almost entirely by Chilean nitrate of soda and by-product sulphate of ammonia. A further study of the data will reveal how unlikely it would have been that these two sources could have coped with this enormous increase in demand. Further, without the competition from the synthetic nitrogen industry prices for nitrogen from these two original sources would almost certainly have followed the general tendency, and risen far above the pre-war level. A natural consequence would have been a further increase in the cost of food. It may therefore be claimed that the synthetic nitrogen industry saved Europe at least from high prices and famine. Reference again to Table 3 will reveal that, in common with other commodities, the nitrogen industry suffered during the depression following 1929–30. Since 1923, when the price of sulphate of ammonia f.o.b. European ports was £17, charges fell steadily. With the advent of the depression, the synthetic nitrogen industry was faced with serious over production, and output dropped to about one-third capacity, whilst a further fall in price to the present level of about £7 per ton f.o.b. European ports for sulphate of ammonia occurred. Since 1931–32, a steady improvement has been taking place, and today production has reached about 50 per cent. of capacity. The consumption figure for 1935–36 of over two million tons represented a record, and nearly a 300 per cent. increase over the pre-war figure.

CONTRIBUTIONS TO RANGE OF NITROGENOUS FERTILIZERS.

The popularity of ammonium sulphate as a nitrogenous fertilizer is evident from the data in Table 3. Its demand is approximately equal to that of all other forms combined. The trend of the curve due to "other synthetic nitrogenous fertilizers", however, is significant, particularly of late years. This is especially noteworthy in the consuming countries of Germany and Holland. In the period 1924–25 to 1935–36, the percentage of ammonium

TABLE 3.—*Estimated Consumption of Nitrogen in Agriculture.*

Figures in 1,000 Metric Tons.

Year.	By-Product Sulphate of Ammonia (Production).	Chilean Nitrate of Soda.	Cyanamide.	Synthetic Sulphate of Ammonia.[1]	Other Synthetic Nitrogen Fertilizers.	Total Sulphate of Ammonia.	Total World Nitrogen.
1903	109	240	—	—	—	109	349
1904	110	242	—	—	—	110	352
1905	120	265	—	—	—	120	385
1906	146	270	—	—	—	146	416
1907	176	272	—	—	—	176	448
1908	180	295	—	—	—	180	475
1909	170	330	7	—	6	170	513
1910	200	350	10	—	14	200	574
1911	200	355	16	—	17	200	588
1912	230	395	17	—	17	230	659
1913	250	400	32	15	23	265	720
* *	* *	* *	* *	* *	* *	* *	* *
1924–25	325	350	140	200	157	525	1,172
1925–26	335	330	160	233	187	568	1,245
1926–27	309	275	179	282	208	591	1,253
1927–28	368	393	202	304	253	672	1,520
1928–29	376	419	218	352	350	728	1,715
1929–30	425	364	218	387	400	812	1,794
1930–31	360	244	182	363	343	723	1,492
1931–32	302	138	145	490	343	792	1,418
1932–33	258	127	176	611	419	869	1,591
1933–34	307	163	196	525	488	832	1,679
1934–35	321	195	224	581	499	902	1,820
1935–36	365	218	262	640	592	1,005	2,077

[1] As consumption figures for *total* sulphate of ammonia, and production figures for the by-product only were available, those for "synthetic" ammonia have been arrived at by subtracting these, and will therefore be generally somewhat on the low side.

(*a*) All figures for sulphate of ammonia include ammonia for mixed fertilizers.

(*b*) Consumption figures 1903–13 taken from graph prepared by Dr. J. Bueb of Stickstoff Syndikat, Berlin; other years estimated from figures prepared by the British Sulphate of Ammonia Federation.

sulphate in total consumption has fallen in Germany from 60 to 23 per cent., and in Holland from 41 to 26 per cent.

Fertilizers gaining in favour include the following :

Lime ammonium nitrate.
Calcium nitrate.
Ammonium phosphate and urea.

Lime Ammonium Nitrate.

Theoretically, it would surely be impossible to conceive of a more ideal compound to select as a nitrogenous fertilizer than ammonium nitrate. Its economic manufacture became possible with the advent of nitrogen fixation—to produce nitric acid, ammonia is oxidized with the aid of a platinum catalyst at 300° C. Unfortunately ammonium nitrate suffers from two disabilities, viz. its hygroscopic and explosive natures. Fairly successful attempts to overcome these difficulties have been made. These constitute its admixture with potassium and sodium chlorides, ammonium sulphate and calcium carbonate. Ammonium sulpho-nitrate, known as Leunasalpeter, was responsible for a memorable explosion at Oppau, Germany, in 1921, when 1,000 lives were lost. This was probably due to the practice, at the time, of blasting the solidified product in storage. However, both it and potassium ammonium nitrate (N=16 per cent., K_2O=28 per cent.) are marketed today in Germany.

Much more successful, however, has been the admixture with calcium carbonate. Most of the European nitrogen factories are now marketing this mixture under various trade names. That sold by Imperial Chemical Industries is known as Nitrochalk, and contains N=15·5 per cent. (half as ammonia and half as nitrate) and $CaCO_3$=48 per cent. The lime renders the compound physiologically neutral, as well as assisting to improve its physical condition.

Calcium Nitrate.

This compound would appear to be more desirable than the sodium salt. It was first made in Norway, where lime deposits occur in close proximity to the arc-nitrogen works. It, too, suffers on account of its hygroscopic nature, but by adding a little ammonium nitrate, granulating the mixture and packing in paper-lined bags enclosed in an outer sack, it is now transported throughout the world, and is attracting an increasing demand. It contains 15·5 per cent. of nitrogen (0·5 as ammonia) and 50 per cent. of $CaCO_3$.

Ammonium Phosphate.

Three ortho salts of phosphoric acid are possible : the mono-, di- and tri-ammonium phosphates. They are formed commercially by passing ammonia into the acid or a solution of the salt. The resultant grade depends upon the

pressure of the ammonia phase. The mono-salt is the most stable, but slightly acid, the di-salt is apt to lose ammonia in solution and is neutral. The tri-salt is more unstable, less soluble and alkaline. The first two are marketed as fertilizers, either in the pure state or mixed with varying quantities of ammonium sulphate. Their high nitro-phosphatic content renders possible the preparation of more highly concentrated plant food mixtures, and they must play an important part amongst fertilizers of the future. Di-ammonium phosphate is sold under an analysis of N=21·5 per cent. and P_2O_5=53·4 per cent., whilst the mono-salt contains 12 per cent. and 62 per cent. respectively. One ton of di-ammonium phosphate contains nearly as much nitrogen and phosphoric acid as 2½ tons of 22 per cent. super and one ton of sulphate of ammonia. Both salts remain dry and free-running under normal conditions. Examples of concentrated three-plant-food fertilizers incorporating di-ammonium phosphate are the so-called Nitrophoskas—made by running a hot solution of ammonium nitrate into mixtures of di-ammonium phosphate and potassium chloride or sulphate. Lime has recently been added to neutralize any acidifying effect of these salts in the soil.

Urea.

During the preparation of pure hydrogen from coal and water, it will be remembered that carbon di-oxide was a plentiful waste product. Actually, however, it is preserved and enters again into two very important reactions. In both cases it is combined with ammonia to form ammonium carbonate, from which :

(1) Ammonium sulphate is made by reaction with gypsum

and

(2) Urea is made as follows :

$$(NH_4)_2CO_3 \xrightarrow[\text{pressure at } 140^\circ \text{ C.}]{\text{heated under}} NH_2\ CO.O.NH_4 + H_2O$$

and $NH_2CO.O.NH_4 \rightarrow NH_2.CO.NH_2\ H_2O.$

Urea contains 46 per cent. of nitrogen, and thus is the most concentrated nitrogenous fertilizer yet offered. When prepared in a pellet form and packed in double bags, it transports fairly well. As it cannot be mixed with super, it offers possibilities chiefly only for " straight " application. It is rather too concentrated for any but the most intensive culture, but as this becomes more widespread so should urea gain in favour.

Agricultural Research Overseas*

SOME ASPECTS OF WHAT SCIENTISTS ARE THINKING AND DOING.

By

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To the Australian who is travelling overseas, one of the outstanding impressions that he receives is the ease with which matured scientists can visit one another to discuss their problems and to exchange ideas. Every endeavour, whether by means of frequent conferences, exchange of positions or by personal visits, is made to foster this important aspect. The perusal of publications, which is often the only method available to the Australian worker, falls very far short of the personal touch in obtaining a new slant on the problems facing each one of us. During my recent visit, the number of new ideas which presented themselves impressed me so forcibly that I do not think a better purpose could be served than to attempt to present some of them to the readers of this Journal.

GENETICS AND PLANT BREEDING.

The attention which is being directed to the study of the subject of genetics, both in America and in Europe, should serve as a sign-post to those concerned with our educational development, not only for its bearing on the practical aspects of agriculture, but also for a better understanding of our own race problems. It may be of interest to review the principal methods used most successfully in plant breeding overseas. Considering, first, self-fertilized plants such as wheat and oats, one must recognize that a hybrid population, when left to itself, will segregate out into a number of homozygous types. If only one factor be involved, for example, the F_2 generation would be 50 per cent. homozygous, the F_3, 75 per cent., and the F_4, 87 per cent. Selection on the basis of single plants, therefore, is the primary phase in improvement when new material is obtained. Selection alone, however, must always be of limited usefulness.

By means of hybridizing, new gene combinations are obtained, and thus the breeder may combine into one variety the desirable combinations. With difficult, complex factors, such as yield, where a number of unknown genes are involved, this desirable combination can only be recognized on the basis of yield trials. The " back cross " method has been used with benefit, where a

* Address to Victorian Branch of the Institute on October 22, 1937.

variety (A) with a known high yield is weak in one character, such as straw, for example. By crossing with a variety (B) with strong straw, an F_1 is obtained which is then recrossed with (A), and the backcrossing process is repeated four or five times. At each stage, plants are selected for the strong straw character, so that the final selection not only has the strong straw character, but also has regained almost the full 100 per cent. of the " blood ", and, therefore, the high yield of the (A) parent.

A further useful method, the " bulk hybrid " method, is in use where an extensive investigation is contemplated. The process was used by Dr. Harlan of the United States Department of Agriculture, who took several of the best barley varieties then known and, by crossing each with every other, obtained a mixed population of F_1, which he allowed to segregate in bulk for eight to ten years. Then, on dividing up the final bulk seed into a number of representative fractions, he sowed a portion in each of the districts throughout the United States. Observation and selection of the resultant plants indicated the desirable strains for each district. This method of " bulk hybridizing " is used more particularly these days in disease resistance work. During the years of segregation, if the plants are grown under conditions suitable for the propagation of the disease, the susceptible types will be weeded out, leaving only the desirable resistants.

It is in the application of genetical knowledge to the breeding of cross fertilized plants, such as maize, that such an excellent illustration is obtained of how the study of pure science may be of real practical benefit. The ordinary " varieties " of maize are heterozygous plants, and any inbreeding will lead to reduced yields. Prior to 1920, most breeding methods were aimed away from any attempt at inbreeding. As early as 1911, East and Shull found that occasionally the low yielding inbred lines, on crossing, produced a hybrid which outyielded the ordinary varieties. They termed the phenomenon " heterosis " or " hybrid vigor ". The present day explanation is in favour of the dominance—favourable gene concept—in which it is maintained that since " high yield " genes are probably dominant (otherwise they would long ago have been lost to the race), the best yielding strains of maize may be represented as Aa, Bb, Cc, Dd, etc., in which the dominant gene is always present in every pair. This can be obtained only when the hybrid is formed from parents either of which contains the dominant gene. It is obviously impossible to reproduce the same resultant hybrid unless homozygous inbred parents are used each time.

AA bb cc DD × AA BB CC dd
↓
AA Bb Cc Dd

High yielding progeny.

AA bb cc DD × AA bb cc dd
↓
AA bb cc Dd

Lower yielding progeny.

Based on these ideas, the whole programme of maize breeding has been revolutionized to produce this " hybrid corn ", and so satisfied are the farmers, and so strong the demand for the new seed, that present prices of " hybrid " seed range around twelve dollars per bushel, as compared with four dollars per bushel for ordinary variety seed. Comparative yields are of the order of :

Inbred selfed strains : 30 bushels per acre.
Ordinary variety seed : 60 to 70 bushels per acre.
Best hybrid seed : 85 to 95 bushels per acre.

By using the method of " convergent improvement ", which involves backcrossing to the desirable parents, it is hoped to improve the inbred lines, and so further increase the yield of the hybrid seed.

Just as in maize, so it is hoped to do similar things with other cross fertilized plants. With potatoes, inbred lines are in the process of formation, and there is evidence of hybrid vigour in the progeny. The position with potatoes is simpler than with maize, since once the hybrid seed is produced, vegetative propagation of the tuber will eliminate any necessity for constant yearly production of seed. The work is also being extended to include lucerne.

An extensive programme has also been initiated with animals, which are also cross fertilized. Inbreeding in animals is obtained with brother-sister mating, but because of the loss in vigour, and the small numbers which are available, most of the lines die out. Occasional outcrossing must be resorted to in these cases in order to maintain the lines. With the larger numbers available in poultry, inbred lines have already been established at the Iowa State College and also in England, and material progress has been obtained with swine.

DISEASE RESISTANCE.

Before leaving the subject of genetics, mention must be made of the important part that it has played in the attack on rust. The work on this problem is concentrated at three main centres, Minnesota (Stakman), Saskatchewan (Harrington) and at Winnepeg. The method of attack will serve as a good illustration of the lines along which disease problems are being attacked in America. The very definite policy of the United States Department of Agriculture has been to concentrate, not so much on preventive or curative treatments (such as the use of $CuCO_3$ for ball smuts) but on breeding resistance to each disease into the high yielding varieties.

We are all familiar with the development of strains within the rust fungus, of the hybridization between them, and of the production of new races. At the present moment there are about 117 known races. Extensive exploration amongst the wheat varieties of the world showed that, while there was little resistance in strains of *Triticum vulgare*, there were two distinct types of resistance in *Triticum durum* and *Triticum dicoccum*. Genetical studies showed

that two separate gene loci were involved, and the problem was then to introduce these genes into *Triticum vulgare*. Because of the difference in chromosome content, these interspecific crosses are difficult to make, and the position is further complicated by the fact that because of linkage between factors, the number of the progeny showing the combination of rust resistance and the desirable *vulgare* character, is small. Working on the " durum " gene, the Minnesota Station produced Marquillo, which was later used as a parent in the production of Thatcher, the wheat which showed out so conspicuously during the epidemic of 1935. The Canadian people have been attempting to combine both gene factors into their crosses, and using Hope (a variety cross between *T. dicoccum* and *T. vulgare*) and Marquillo as parents, have evolved other wheats which are even more rust-resistant than Thatcher.

The position with regard to these interspecific crosses has changed considerably in the last few years. The former approach was to obtain one hybrid, and test large numbers of F_2 and subsequent progeny for rust resistance. Because of the better understanding of linkage, the work is now concentrated on the hybridization, upwards of two to three thousand crosses being made. Rust resistance is tested immediately, and rigid selection is practised, with the result that only 20 to 30 of the original number are carried on for yield testing.

The presence of strains also is being demonstrated in a number of the fungi. In bunt, which is a very serious disease in western United States, there are, at the moment, at least eleven races of *Tilletia tritici* and eight of *T. levis*. Control methods, consisting of pickling with mercuric powders, which give more effective results than copper poisons, are nevertheless not completely efficient, and genetical studies are resorted to again. Extensive tests showed that two varieties, Oro and Ridit, were very resistant. Moreover, those races to which Oro was susceptible were not able to infect Ridit. The next steps of testing the hybrid between Oro and Ridit showed complete resistance in one of the selections, so that the problem is well on the way to solution.

GENERAL RESEARCH.

A series of extensive trips into some 40 of the 48 United States enabled one to make many interesting observations. One noticeable feature was that American State Universities, which control the State experiment stations, tend, as a policy, to concentrate on special problems more than we do. For example, Minnesota specializes on rust and wheat quality, while statistics and animal and plant breeding are the most important research problems at Iowa. It is indicative of the fact that problems tend to become regional, and the United States Department of Agriculture, recognizing this, has adopted a decentralization tendency, in which regional laboratories are set up at the State experiment stations (barley at Wisconsin, Soy beans at Illinois) together with a general policy of stationing men, whose salaries are paid partly by the

Federal Government and partly by the State, at each of the experiment stations in the region. An unquestioned feature of this practice is the complete harmony and understanding between both parties.

It was gratifying to hear the many favourable opinions of Australian wheats in the West Coast areas of the United States, where the climate and the type of wheat are similar to our own. Varieties of Federation and Hard Federation type have assumed major importance, and are the most popular wheats in many counties. A new selection, White Federation, which had been sent to California by Mr. H. Wenholz, of the N.S.W. Department of Agriculture, was regarded as the most promising new variety on hand. One could not but be impressed with the fact that in those fields in which we were working Australian scientists and Australian experiment stations were more than holding their own with overseas workers. That there were many fields of work in which we were not doing much could not be gainsaid, but with more workers and greater financial support, that undoubtedly will be remedied.

CULTIVATION AND SOIL EROSION.

The important field of soil erosion is receiving much attention at the moment in the United States, but as that has been the subject of a recent article in the *Victorian Journal of Agriculture*, there will be little point in repetition here. With regard to the control of water erosion, it is of interest to note the opinion held by those in authority that the building of artificial dams and breaks is not proving as economical or as efficient as the more ecological methods of getting the soil under vegetation. Assisting nature to do her work is proving better than man's engineering skill.

The methods of " strip cropping " and " ploughless fallowing ", though excellent from the point of view of controlling wind drift in cultivation areas in Canada, are bringing in their train many new disease and insect problems. One point arose while I was at Lethbridge, Canada, that may be worthy of investigation. Experiments at that centre have failed to show that ploughing of the soil is any better than the cheaper method of scarifying. Not only did the crop show just as good growth on the scarified area, but also the wild oats—which had always been a problem in the district when ploughing was the practice—had practically vanished when the scarifier alone was used. The same fact was put to me by Veihmeyer, working at Davis, California, who has there a very successful plot of sugar beets growing on soil which has only been scarified for the last ten years. The work of Veihmeyer and his school was most impressive.

EXPORT WHEAT AND QUALITY.

While in England, I had the opportunity of talking to various millers and of visiting the laboratories of the Research Association of British Millers at

St. Albans. The opinion of the trade was definitely against Australia attempting to enter the strong class. The price movement which set in against No. 1 Manitoba Hard Red a year ago, when the supply was excessive, shows that there is a definite saturation point for that class of wheat. The English market needs two other grades which Australia can well concentrate on, (*a*) " filler " wheat of about 10 per cent. protein, which is used for blending with strong flours. This is supplied mainly by Platte wheat at the moment, but as this is often very dirty and unsatisfactory, the market would welcome other supplies. This class of wheat is very little higher in protein than our good wheats at the moment. The other grade, (*b*), is the soft " weak " wheat market which we supply now. Our present F.A.Q. system is decidedly out of favour in England. Consistency in type and quality is essential in the milling trade. The English miller knows what to expect when he buys Manitoba No. 1, whereas he must inspect every parcel of Australian wheat before he can be certain of its nature.

With the continued study of flour quality, the position is gradually becoming clearer. As a result of discussion of the situation with Dr. Halton of the St. Alban's laboratory, and Drs. Bailey and Markley at Minnesota, the following summary would express the ideas held in these two countries. In the past, confusion has arisen from the fact that due recognition has not been given to the three distinct phases of bread making, viz., the fermentation and production of gas, the absorption of water and working of the dough, and finally the actual physical quality of the proteins in the dough. Any test which attempts to measure all three phases at once must give uncertain. results. For this reason, the Pelshenke method leaves much to be desired In any case, since maltose and improvers are generally added by all bakers, the question of gassing is not as important as the other two phases.

Dealing, as they do, with wheats of vastly different origin and type, those workers have had difficulty in interpreting the graphs from the Brabender Farinograph, which tends to measure the two latter phases at the one time. Both laboratories are developing independently a somewhat similar type of machine to test dough quality alone. It is termed an Extensimeter, and is designed to measure the actual shear modulus (the elasticity) and the viscosity (ability to flow) of the dough after mixing. " Spring " and " shortness " are considered by bakers to be the two important characteristics in baking. Dr. Halton considers that a good measure of the former is given by the ratio of the viscosity to the modulus, which he has termed the " relaxation time ", while a measure of shortness is indicated by the rate of fall of viscosity with increasing stress. The English Research Association is preparing to put its machine on the market in the near future at an approximate cost of £50, and has already had a number of orders from British millers who appear very satisfied with its performance. The workers at the United States Department of Agriculture, Washington, are concentrating largely on low quality

work at the moment, and have had considerable success with an " Index of Particle Size " test.

CROP ESTIMATION AND FORECASTING.

A further important subject which is engaging the attention of scientists both in America and England is the question of crop estimation and forecasting. Schemes of crop marketing and controlled production must necessitate a fairly accurate knowledge of total quantities likely to come on the market. The sooner the knowledge can be gained in any given season, the better. The American practice of publishing percentage estimates of crop normality is based on observers' returns, which have been shown to be subject to bias, and therefore unreliable.

The problem is twofold in nature : (*a*) the estimation by systems of sampling in place of eye judgment, and (*b*) the determination of the relationship between weather, crop development and final crop yield, with the hope that forecasts may ultimately be given. English workers at the Empire Meteorological Conference, about 1929, commenced on the problem, and samples of growing crop were gathered from plots sown at various centres throughout the country. The method is based on that developed first by Engledow and Wadham at Cambridge in 1921, and used subsequently by Vasey and myself in Australia since 1927. In America, with the present stress on regulated production and marketing, a new section of the United States Department of Agriculture has recently been formed to initiate the programme there. The work in England is being carried on under the direction of Yates at Rothamsted, and, although it is rather early to talk of results, fair success has attended efforts in estimating the standing wheat crop in England. Dr. Barnard, during her stay in England, showed that certain factors, such as height of straw at ear emergence, bore a high relationship to final yield. The scope during recent years has been extended to include such crops as sugar beets and potatoes.

THE INTERNATIONAL GRASSLANDS CONGRESS.

The recent International Grasslands Congress, which was held at Aberystwyth in July, was attended by some 450 delegates from 37 different countries, and proved most interesting and profitable. The excellent organization was a just tribute to that able person, Wm. Davies, who asked very kindly after his many friends in Australia. The opinion of the English workers on pasture, as embodied in several addresses by Prof. Stapledon during the Congress, may be summarized as follows :

The trouble with pasture development in the past has been that most of the improvements have resulted in further increasing the peak of production, generally at a time when there is plenty of grass available anyway. Greater concentration must be directed in the future to boosting up the slack periods

and evening up production. Pasture improvement may be divided into three phases, seeds, soil fertility, and management. As far as seeds are concerned, we must look to the district stations to develop their own particular strains, rather than to hope that one central body of workers should produce a type for widespread use. The tendency at the moment is for grass mixtures to become simpler, and the aim has been to study the peak periods of production of each species so that production may be spread as evenly as possible over the whole year. Prof. Stapledon laid stress on the fact that as one who had depended almost solely on selection for the propagation of new strains, he was satisfied that selection alone, although successful in the early stages, failed to " deliver the goods " in subsequent phases. Hybridization was essential to incorporate the desirable genes from a number of lines into any one given line. Those who are familiar with the cereal side will recognize the force of this advice.

On the fertility side, the " scratching in " of clover together with superphosphate top-dressing forms the basis of any scheme of improvement, and the subsequent grazing is far better than widespread application of manures. After some years of good clover growth, ploughing and sowing down with better types of grasses and clovers will follow. Concentration on small areas is thus the keynote.

Management is considered to be the most important phase, and must be aimed at preserving the desirable mixture, and spreading the production curve over the longest possible period. Since any one given system of management must inevitably encourage one type of grass, Stapledon advocates a " rotation in time ". If a paddock be shut up for hay one year, it should be grazed the next. If grazed heavily in autumn one year, it should be grazed heavily in spring the following year.

Grass drying attracted much attention among both English and Continental workers. Although the value of dry grass as a concentrate is beyond question, the difficulty at the moment is cost of production, which is about £6 to £8 stg. per ton. The output of the grass drying machines at present is only of the order of two hundredweights per hour, and this results in the grass being left too long before cutting, and means production of super hay of about 10 per cent. protein rather than dry grass concentrates of 16 to 20 per cent. protein. A development which may be of interest to graziers in Australia is the production of grass nuts, formed by chaffing the short grass, mixing with 5 per cent. molasses, and pressing in a screw press at temperatures of 80 degrees Fahrenheit.

EXPERIMENTAL DESIGNS.

Without going into too much detail, I should like finally to present some of the newer aspects of experimental designs and methods. Randomized blocks and latin squares are by no means limited to the plant world. The former design has been used frequently for feeding experiments with pigs.

At Cambridge, I saw an innovation in a latin square design for testing the effect of ration on milk production of cows. Too much stress cannot be placed on the importance of the use of factorial designs, about which several articles have recently been published. Apart from the economy in number of plots, and the increased information available, not the least valuable gain is the subdivision of the treatment effects into their component parts. In suitable designs, each one of the independent comparisons between the different treatments, i.e. the treatment degrees of freedom, can be separated and tested for significance. Too often in the past has the significant effect of one treatment been overwhelmed in the analysis of variance by other non-significant treatments, with the result that the composite treatment mean square has been insignificant.

The outstanding new phase, to my mind, has been the development of what has been rather forbiddingly termed " discriminate functions ". Professor R. A. Fisher rather delights in these terms, which, though technically correct, are apt to terrify the uninitiated. Its use promises to be of the widest—from the comparison of various dynasties of human skulls to the merely agricultural attempt to give an index value to a wheat variety, or to the breeding qualities of a bull. The particular phase of the wheat variety application was presented in a recent article by Mr. Fairfield Smith. From a plant selection point of view, a wheat variety has a number of desirable characters, such as yield, number of ears produced, size of ear, weight of grain. The cow has certain attributes, such as yield of milk, percentage of butter fat, etc. In determining the discriminate function, we not only obtain an overall index value of these attributes, but also an indication of the proportionate value of the different component attributes. It may also be possible to determine that one attribute is more valuable under one set of conditions (say district) than another. Until these various avenues have been explored, it would be unwise to claim too much for the method, but the possibilities appear to be there.

I am afraid neither time nor space will permit me to tell of the many other interesting phases—of the work of the Boyce Thompson Institute on plant hormones, or as they are now termed, growth promoting substances, of the work on epinasty, and the shortening of the rest period in potatoes and other tubers, of the more recent ideas on the nature of virus in its relation to gene structure, of the possibilities in the new potato varieties from Peru, and so on. In closing, I would like to say how pleasant and obliging I found all these redoubtable scientists, and to record my sincere appreciation of the generosity and thoughtfulness of the Commonwealth Fund of New York.

Agricultural Development in South Western Australia*

By

Professor A. E. V. Richardson, M.A., D.Sc.

CLIMATIC AND SOIL FEATURES.

The south-western area may be divided into three main zones: (1) a high rainfall zone receiving a mean annual rainfall of 25 inches and over, with highly leached podsolized soils and a vegetation cover of karri, jarrah and marri; (2) the mixed farming belt with 15 to 25 inches, and vegetation comprising wandoo and mallet, York gum and jam (*Acacia acuminata*); (3) the wheat belt proper, with 15 inches or less, on red to brown sandy loams broken by sand plains and salt lake systems, with salmon gum, gimlet and morrel.

The marked winter incidence of the rainfall and its high degree of reliability are important features of the climate. Even in the wheat belt proper, the rainfall is more intensely seasonal and more reliable than in the remaining wheat areas of Australia, leading to relatively consistent average wheat yields.

The soils of the higher rainfall areas are highly leached and of a sandy or gravelly nature for the most part. It is probable that they are generally low in both nitrogen and phosphorus.

Three reservoirs have been constructed for purposes of irrigation. These are the Waroona, Harvey and Collie dams, which together possess a total capacity of 11,500 million gallons and command an irrigated area of about 60,000 acres, of which considerably less than one-third has yet been developed for irrigation. The coastal plain, some 15 to 25 miles in width and 150 miles in length, with the catchment areas of the Darling Range on the east, offers opportunity for a considerable extension of irrigation.

AGRICULTURAL DEVELOPMENT.

The area of greatest interest for future development is a triangular portion 240 miles in length and 120 miles across at its broadest part, bordered by the Perth-Albany road and the Indian and Southern Oceans. The rainfall throughout this area exceeds 20 inches, but apart from selected pockets of fertile land near permanent water, the soils are poor, sandy, gravelly and lateritic in type and contain very little organic matter, nitrogen and phosphate. The key to the development of these lands is the use of pioneer legumes such as sub-

* Outline of an address to the Agricultural Sciences Club, Waite Research Institute, on October 28, 1937.

terranean clover and lupins, together with liberal fertilization with superphosphate. Clearing is effected by the ringing of the larger trees and the burning of the undergrowth. A light stirring of the surface soil usually gives better results than ploughing, except where the soil is reasonably fertile, and the land is sown with inoculated seeds.

The use of liberal dressings of superphosphate is important. There is abundant evidence that increased dressings will greatly hasten the development of a continuous cover of clover.

DEVELOPMENT OF HERBAGE PLANTS.

As the fertility level is improved, it should be possible to introduce associate grasses into the sward with marked advantages to the stockowner. There is, however, a marked absence of seeded pasture grasses in the south-west of Western Australia. Under irrigation, *Paspalum*, perennial rye-grass, cocksfoot and *Phalaris* have been successfully employed with white clover, but comparatively little rye-grass or *Phalaris* has been seeded with subterranean clover. Some excellent small plots of *Phalaris* were seen at York.

The blue lupin has been used extensively on the poor, light sandy soils. It is extraordinarily vigorous, and with one hundredweight of superphosphate in a good season will form a complete cover three to four feet in height. On the Yatheroo Station, west of Dandarrigan, no less than 10,000 acres were under lupins this year.

Drooping-flowered clover (*Trifolium cernuum*) is particulraly well adapted to the swampy areas which are of common occurrence in the south-west. The clover appears to be well suited to waterlogged conditions. The germination capacity of the seed is raised from less than 1 per cent. to more than 60 per cent. by scarification.

In the wheat areas, burr trefoil (*Medicago denticulata*) and barrel medic (*M. tribuloides*), cluster clover (*T. glomeratum*) and woolly clover (*T. tomentosum*) are common where liberal dressings of superphosphate have been applied. Wimmera rye-grass grows extremely well on the heavier soils of the wheat belt.

MINERAL DEFICIENCIES.

Several interesting mineral deficiencies have been investigated; these include zinc deficiency in *Pinus pinaster* on the coastal plain at Myalup, and in citrus grown in the Carrington locality. The deficiency is readily overcome by the use of zinc sprays.

The Denmark wasting disease has been shown by Dr. Filmer and Dr. Underwood to be due to a deficiency of cobalt in the diet, and this disease is thus comparable with the bush sickness disease of New Zealand.

The so-called Gingin disease appears both by spectroscopic tests and actual feeding trials to be due to copper deficiency. Dr. Bennetts has shown

that dosages of copper are particularly effective in the control of this disease in sheep. Foals are also affected by the disease, and the common symptoms are swollen knee joints, a form of ataxia and a stilted gait. Doses of copper bring about an immediate improvement. Dr. Bennetts has also established the cause of Beverley disease, and a serum has been developed which is effective in its prevention.

INVESTIGATIONS IN PROGRESS.

The small but keen staff of the Department of Agriculture is greatly handicapped by lack of accommodation, equipment and facilities.

Soil work, under Dr. Teakle, includes salinity surveys in the wheat areas, the irrigation areas watered by the Waroona and Harvey dams, and the Denmark and Gingin areas ; the latter, which have now been completed, were carried out in co-operation with the Soils Division of the Council for Scientific and Industrial Research.

The Millers' Association has presented the Department with a Brabender plant costing approximately £1,500, for the testing of the baking qualities of wheat. Dr. Samuel has received a special training in cereal chemistry and should be able to carry out valuable work in raising the level of quality in wheat.

In regard to plant nutrition, dieback of apples is being investigated from the nutritional aspect by Dr. Dunne, but it is too early as yet to form any opinion as to whether a nutrient deficiency is the cause. The West, as already indicated, appears to be a happy hunting-ground for mineral deficiencies.

Excellent work is being done by Mr. H. A. Pittman in the propagation and distribution of cultures for leguminous plants. Cultures are distributed for (*a*) lucerne, (*b*) subterranean clover, (*c*) lupins, (*d*) peas and beans.

Investigations of the red-legged earth mite are in progress. These include a survey of the possible effects of variation in cultivation and management of pastures on the distribution of the mite.

In regard to the University, Professor Nicholls, who, prior to his appointment, was engaged in research work on wool at Torridon, has naturally taken an interest in sheep and wool problems. Investigations include (1) the growth and conformation of Merino sheep in relation to environment, (2) the cause of " tenderness " and " canary stain " in wools from the pastoral areas. The most interesting investigations, however, are those relating to the digestibility of natural fodders such as mulga, spinifex and saltbush from semi-arid areas. This work should be of considerable interest and importance.

Noxious Weed Investigations

CONSIDERED AS A NEGATIVE PHASE OF AGRICULTURAL RESEARCH

By

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While the importance of investigating noxious weed problems is generally admitted, the scope of the subject and its relationship to other departments of agriculture are by no means clearly understood.

The concept " weed " is not a botanical one ; it simply exemplifies a natural, human taste for nouns in preference to verbs. Many factors determine our attitude towards a particular plant : whether we feel we should encourage or destroy, or merely ignore it. The nature of our conduct, as prescribed by the factors referred to, cannot therefore be ascribed, logically, to the said plant as an intrinsic character. While it is customary, perhaps, to speak of " controlling a weed ", it would be more logical and more scientific to use some such expression as " repressing a plant ", or, in other words, to detach from the noun the notion of repression, and connect it to the verb, to which it rightfully belongs.

Such an usage enables us to see at a glance the relationship between weed investigation and agriculture in general. For, if we conceive the latter to mean *promotion* of the growth of certain favoured species, either as crops or pasture plants, then we have, in *plant repression*, an obvious antithesis to this ; and we are led to the conclusion that the repressive control of plants considered undesirable constitutes a negative side to agriculture, or, in short, that an investigator of weed problems is, so to speak, an agriculturalist *turned back-the-front.*

Theoretically this conclusion is quite sound, and, up to a point, it has a practical value. But if, beyond this point, one attempts to use it as a basis for research, difficulties are met with which, while not affecting the theoretical validity of the relationship, raise the question of to what extent noxious weed research can be pursued within a category of its own without becoming a purely academic study. But if we accept for the time being the view that weed control is agriculture " reversed ", or in its negative phase, it follows that the first is as comprehensive in scope as the second, and that every department concerning itself with a positive aspect of agriculture is capable of being extended into a corresponding negative phase. For example, if agricultural research, in its entirety, is to be depicted graphically as a series of lines diverging

upwards from a point situated on a base line, each line being taken to represent a single department, e.g. entomology, plant pathology, agronomy, etc., then the graphical representation of noxious weed research can be effected, quite simply, by producing each and every one of these lines to a distance below the base line, through the original point which now becomes one of intersection. Such considerations suggest that it is only by developing the negative phase of each branch of agriculture that adequate attention can be given to the problems connected with weed growth.

Thus far entomology alone—if we exclude agronomy as belonging to a somewhat different category—has achieved an approximately equal development of both positive and negative phases, by contributing as substantially towards the eradication of weeds, as towards the production of crops. While seeking to *prevent* the attacks by one set of insects upon crop plants, the entomologist has *encouraged* the attacks by another set of insects upon weeds. And this lead could well be followed by other departments. Plant pathology, for instance, is theoretically capable of similar development. The use of chemicals as weedicides is a negative counterpart to the use of fertilizers in crop production ; in fact, every fertilizer, to the extent that it is selective, is at the same time herbicidal in its action. Even the geneticist might try his hand at linking together, say in Cape Tulip, an increased susceptibility to chemical weedicides and certain of the characters determining its aggressiveness in competition with other species.

DIFFICULTIES ATTENDING A RESEARCH PROGRAMME.

But certain difficulties of a practical nature, to which reference has already been made, hinder the full development of research along these lines. There are practical difficulties, for example, in the way of sowing noxious weeds on clean land, as one would a crop of wheat. Such a procedure, obviously, would not be advisable without effective control. This means, in effect, that it would be permissible only if, *at the outset, we were in possession of the information which the experiment would be expected to supply*. This consideration removes any hope we might otherwise entertain of accumulating a supply of data comparable with the vast store of facts ascertained with respect to the growth of useful plants under different manurial treatments. Something along these lines might, of course, be done in the case of the relatively harmless weeds ; but, for the more serious plant pests, except on a very small scale as, for example, by growing them in pots, it would be entirely out of the question. Thus, one very necessary condition for exact experimentation, namely the *initial density* of growth of the species, cannot be controlled ; *the weed, not the experimenter, determines in this case the conditions under which an experiment shall be undertaken.*

Then there is the difficulty of measuring negative yields. Even if it were practicable to sow weeds as crops with a view to measuring, subsequently,

the effects of a range of herbicidal treatments, it would not be possible to achieve the same standard of refinement in respect of experimental technique, as in the case of economically useful species, whose relative yields are easily determined. Relative yields could, it is true, be used indirectly to measure traumatic effects ; but such yields would not be as good an *inverse* measure of the degree of susceptibility to injury as they are a *direct* measure of response to fertilizer treatments in the case of crop plants. If negative experiments of this kind were to be undertaken, that is to say, if the attention of the observer were to be focused upon the weed, and the results expressed in terms of its varying symptoms of susceptibility to the treatments applied, the degree of precision achieved by the research would, even under the best of conditions, be somewhat less than that attained in the case of positive experiments with crop plants. Under actual conditions, where such things as locality, soil conditions, and initial density of growth are determined by the distribution of the weed and are not subject to control by the experimenter, the scientific value of the results gained would be very greatly reduced.

This does not mean, of course, that experiments with weedicides are not worth while, as, in fact, they are ; it merely illustrates the point that they represent experiments undertaken from a wrong angle ; that the task, in short, is being entrusted to the wrong person. It seems that in work of this kind the focus of attention should be not upon the weed primarily and the treatment secondarily, but *vice versa* ; and that the results should be expressed in terms of the treatments rather than in those of the species experimented upon. In other words, this type of experimentation should set out to determine the efficacy, as weedicides, of certain chemical substances—e.g. chlorates, arsenical compounds, etc.—by applying them in different ways, in different amounts and concentrations, and under different conditions as regards soil, climate, etc., to weeds of various kinds, in different stages of growth, and with different areas and densities of distribution. The susceptibilities of particular weeds could then be ascertained by cross reference, so to speak, to the results of a series of such experiments using different chemical substances. In short, the task is one for a chemist rather than for a botanist.

Another difficulty, a psychological one, which arises from the essentially negative character of weed problems, is connected with the factor of time. On the positive side, research into the problems of crop production can be carried on side by side with the growth by farmers of crops on a commercial scale. In the course of time, the results gained by such research become embodied in general farming practice and lead to increased average yields per acre. While in retrospect it might be possible to calculate what a given improvement in technique would have been worth to the State in years prior to its introduction, the disabilities experienced by commercial production during the experimental period would not, at the time, have been ascribed

to lack of the technique referred to. The farmer does not exhibit impatience whilst awaiting the results of such positive research ; indeed, many instances could be cited of reluctance on the part of farmers to adopt new methods which they subsequently found to be highly profitable to themselves. Very different, however, is the case with research work of the negative type, such as is exemplified by the investigation of noxious weeds. The demand for the control of weeds and, in fact, of pests in general, is usually urgent and immediate. By the time that the population of a district has become impressed with the need for active measures against a particular plant, the extent of its invasion will, in most cases, have reached a stage where the time factor is all important. We cannot very well say to these people : " We are undertaking experimental work with a view to eradicating this weed, and may be in a position, five years hence, to supply the information you so urgently desire ; in the meantime, just carry on as best you can." They might well reply : " In five years' time, the magnitude of the task of eradication may have grown out of all proportion to that of the existing problem."

SPECIFIC NATURE OF WEED PROBLEMS.

Added to the time factor is the further difficulty of the specific nature of most weed problems. It is not always easy to relate the immediate problem of eradicating a particular plant, growing in a particular place, to the general principles underlying the scientific extermination of the same weed. The economic factor enters so very largely into weed questions that eradication measures, however effective they may be under experimental conditions, are often made impossible of application in practice by considerations of cost. With weed problems, often the demand is not so much for general knowledge as to how an offending plant can be got rid of, as for economically practicable methods of dealing with particular cases of weed infestation. The same plant may be involved in a number of cases, and yet the problem is fundamentally different in each. In addition to such economic factors as the cost of treatments to be applied and the value of the lands infested, the specific nature of most weed problems is determined by various other factors, such as the nature of the weed itself, the extent and density of its growth, soil and climatic factors, the use to which the land is to be put, the topography of the ground, the botanical composition—apart from the weed—of the area infested, and the willingness, or otherwise, of the owner to sacrifice more valuable plants, if necessary, in order to ensure the complete destruction of the weed growth.

When one considers the multitude and variety of the problems presented, in conjunction with the urgency of the demand for their solution, it becomes evident that the opportunities for experimental research into weed problems are much reduced in comparison with those offered by the positive phases of

agricultural work. And one becomes impressed with the need for some provisional technique which will serve the immediate needs of the public as regards weed control, and under cover of which a more sound and reliable technique can be gradually achieved in the light of knowledge gained from experimental research. Such a provisional technique could be acquired by enlisting the services of landholders as pioneer experimentalists, and by encouraging them to try out the methods of attack upon weed problems which theoretical considerations suggest as being the most suitable in each particular case. The experience so gained could then be made the starting point for research work of a more scientific character.

It has been said above that agronomy belongs to a different category from entomology, in respect to the potential development of its positive and negative phases. This difference distinguishes agronomy, not merely from entomology, but also from all other departments of agriculture not concerned with the factor of competition between plant and plant. In all of the latter the two phases are essentially different from each other, so that it is necessary to " turn back-the-front " in moving from the one to the other. But where the factor of competition enters the picture, the positive and negative phases of work are sufficiently alike to make it unnecessary to do so in practice, though in theory one should still reverse one's direction of view in passing from the sphere of pasture improvement to that of weed eradication.

Pasture research aims at promoting the growth of certain favoured species, which we may call A, B, and C, whilst depressing that of others, D, E, F . . . Z. In the positive type of experiment A, B, and C are specified, sown at the rate of so many pounds of seed per acre, top-dressed with so much fertilizer, and so on. On the other hand, D, E, F . . . Z are not specified, and vary in numbers and composition from experiment to experiment. Progress of an experiment is recorded in terms of the growth and yield of A, B, and C. In a given example, A, B, and C might stand for Wimmera Rye-grass, Phalaris and Subterranean Clover, respectively, whereas D, E, F, etc., might be represented by Cape Tulip, Barley Grass, Salvation Jane and other weeds. The positive type of experiment would be concerned only with the establishment of the Rye-grass, Phalaris and Clover, and its progress would be described in terms of increasing densities and yields of these species. But now, assuming it to be necessary for agronomy to develop its negative phase in order to undertake research into noxious weeds, one can visualize an experiment in which the control of, say, Cape Tulip, Barley Grass and Salvation Jane is attempted by subjecting them to competition with the three abovementioned pasture plants along with other grasses, etc., of minor importance. Accordingly, an established pasture of Wimmera Rye-grass, Phalaris and Subterranean Clover is ploughed up and then sown with so many pounds of seed of each of Cape Tulip, Barley Grass and Salvation Jane. Top-dressings are given with chemical substances designed to depress the growth of the sown species, which, in this case, are

represented by A, B, and C, relatively to that of the pasture species, now indicated by D, E, F, etc. Progress of the experiment is recorded in terms of the progressive diminution in numbers of A, B, and C. An outside observer might well be tempted to ask whether there is any fundamental difference between the two types of experiment, and whether the two sets of data might not have been obtained, equally well, from the first experiment.

The point here is that in agronomy, which is essentially a study of competition between plants, both the positive and the negative aspects of the struggle are simultaneously present and inseparable. The one experiment may be interpreted either from the viewpoint of promoting the growth of useful species, or from that of depressing the growth of relatively useless or harmful plants. Nothing is to be gained in this case, therefore, by turning back-the-front, that is, by interchanging A, B, and C for D, E, and F. Agronomy can play a part in noxious weed investigation without developing its negative phase. All that it need do is to enlarge the scope of its positive phase by substituting, for the unspecified components D, E, F, etc., certain specified noxious weeds.

THE BOTANIST'S PART.

There remains the question of how much of the noxious weed problem belongs to the province of botany. The competitive aspect, clearly, is inseparable from agronomy. Exploration of the possibilities of chemical control is a task for the chemist. Biological control by means of insects belongs to entomology. Development of the negative phases of other branches of agriculture would, no doubt, account for part, at least, of what remains. Is there, then, any residue left for the subject of botany? Certainly there is; but it cannot accurately be spoken of as a residue. The botanist's contribution is represented by the intensive study of the plant itself. His task is to supply the known facts relating to its structure and habits of growth, the configuration of its root system, its physiology and ecology, its systematics and affinities, its properties, its methods of perennation and of reproduction, and its life history. So far from being a residue of work to be performed after others have done their share, the botanical data are a necessary preliminary to the more specialized work of other departments; so much so that in their initial stages the problems are, in fact, almost exclusively botanical. But in their later stages they pass well beyond this sphere. The most the botanist can be expected to do is to determine the vulnerable characters of each particular weed, and on the basis of these to suggest suitable lines of attack. Two facts should be borne in mind by those who would assign to the botanist a more actively experimental rôle in noxious weed investigation. One is that almost every plant must be regarded, botanically, as a potential weed; the other is that the necessary botanical data with respect to a particular plant should be ascertained in advance of its falling under suspicion as a weed.

Some Aspects of the Root-Rot Problem in Wheat

By

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Factors governing the occurrence of seedling blight in wheat, through invasion by the fungus *Helminthosporium sativum*, are more clearly understood than those governing disease development in adult plants. The planting of wheat in infested soil under either field or glasshouse conditions usually results in appreciable reduction in emergence, but the extent to which surviving plants will develop root-rot symptoms in the later stages of growth has not been clearly defined by any investigator for particular sets of conditions. In fact, no work has yet been published in which experiments on factors governing root-rot development in *adult wheat plants* in a controlled environment are described.

Since foot- and root-rot is usually much more serious in the later stages of the plants' growth, information on infection and disease development during that period is important. This aspect has been investigated by the writer over a period of years, and the following is a brief review of the more significant results obtained from experimental work. A full account of these investigations will later be published as a Science Bulletin of the N.S.W. Department of Agriculture.

INFLUENCE OF CLIMATE.

Little information has been made available in published work concerning the effect of climatic factors on *Helminthosporium* root-rot development in adult wheat. The use of some system which expresses in a single numerical index at least some of the factors concerned in climate would prove of distinct value in epidemiological studies. In this connection the Meyer ratio of precipitation to absolute saturation deficit $\left(\frac{P}{s.d.}\right)$ was studied by the writer in relation to the incidence of foot-rot in wheat over a period of six years at Bathurst. While ratios and observations for other localities would be required in order to draw definite conclusions, the data for Bathurst indicated quite clearly that the incidence of the disease was more marked when the ratio of precipitation to saturation deficit was relatively low during the August-October period.

Many climatological factors no doubt are involved in the occurrence of epidemics of soil-borne diseases, but it became apparent from extensive field

observations in New South Wales that the incidence of the annual rainfall could in many instances, be interpreted to explain the relative severity of *Helminthosporium* root-rot in different years in this State. Accordingly, the disease situation and the rainfall records for the ten-year period 1924 to 1933 in portion of each of the four main wheat-growing sections of New South Wales (North Western Slopes, Central Western Slopes, South Western Slopes and the Riverina) were analysed closely. The accumulated data showed that foot-rot was prevalent or moderately prevalent in those years when the rainfall in the growing period of the crop (April to October) was, in general, less than or in excess of 10–11 inches. From a study of the distribution of rainfall during the early and later periods of the growing season, it was not possible to conclude whether early rains were more important than late rains in respect of disease occurrence, or *vice versa*. Observations for numerous individual localities also supported the generalization based on the district surveys, *viz.*, that foot-rot is usually more severe when the April-October rainfall is low or high.

The data obviously could only be used to indicate in a very general way the relationship of rainfall to disease incidence. Moreover, the effectiveness of rains is dependent on so many factors of soil and climate which could not be reckoned with in the general survey. Therefore, glasshouse experiments were designed to ascertain the influence of the soil-moisture factor under controlled conditions on foot-rot development in adult wheat, and these were conducted over a three-year period.

EFFECT OF SOIL MOISTURE.

The tests were arranged so that in control and inoculated series there were sets maintained at low soil-moisture content throughout growth ; at high soil-moisture throughout ; at low moisture until the ear-peeping stage, when a high moisture content was then maintained until maturity ; and at high moisture content until the ear-peeping stage, being then maintained at low moisture until maturity. Typical wheat soil was used throughout. It was hoped by these means to secure information which would be of value in interpreting the occurrence of epidemics under field conditions.

In analysing data, attention was given to plant height and tillering, ear-peeping date, approximate ripening date, yield of grain, root development and basal stem lesions, but the most constant feature for assessing differences was average height of plants. The humid conditions of the glasshouse at the time of flowering resulted in quite variable degrees of grain setting, so that differences in yield of grain could not always be relied upon in drawing conclusions from the tests. Nor could severity of disease development be correlated with basal stem lesions which in all cases proved to be quite variable in extent of development.

The original experiments showed that when the water-holding capacity during the pre-ear-peeping stage was high (60–65% W.H.C.), the parasitism of

H. sativum was negligible, whether the moisture content in the post-ear-peeping stage was high or low. This negligible effect was reflected in data for both height and grain yield. But when the soil-moisture content during early growth was low (30% W.H.C.), the results showed that the pathogen had exerted an effect which was more pronounced in the set adjusted to a high moisture content in the late stages of growth than in that maintained at the low moisture content throughout growth. It was also apparent that the difference between control and inoculated containers in respect of the final number of head-producing plants was much greater when the moisture content was low during early growth than when it was high. In all cases diseased plants ripened earlier than uninfected plants.

SOIL MOISTURE AND SYNERGY OF ORGANISMS.

In view of the results from seedling tests in which root-rotting fungi were combined in inoculation, and in view also of the fact that in a preliminary experiment it was found that root-rot in adult wheat plants was more pronounced when soil was inoculated with *H. sativum* + *Fusarium* sp. than when *H. sativum* acted alone, it was considered essential to ascertain the effects of varying soil moistures on disease development in the late stages of growth when organisms were inoculated in various combinations.

The fungi *Helminthosporium M*.*, *H. sativum* and *Fusarium culmorum* were used, and soil moisture adjustments were similar to those referred to above in connection with tests on *H. sativum* alone. Considering first the results for the wet-dry series, it was apparent that most severe stunting occurred where all three organisms were combined in inoculation. Some degree of stunting also occurred in other containers, but the decrease in height in each was not so striking as in the case just mentioned.

In the dry-wet series, however, not only did the greatest amount of stunting occur in those containers in which the three fungi were incorporated, but the decrease in height was greater than that which occurred in the case of similarly treated plants in the wet-dry series. It was also observed that when *Helminthosporium M.* and *H. sativum* were combined in the one container, the reduction in height of plants was greater than when either organism was used singly, and this decrease—though not as marked as when three fungi were inoculated together— was quite appreciable.

In another series involving inoculation with *H. sativum, Ophiobolus graminis, Fusarium* sp. and *Penicillium* sp., it was likewise found that stunting was most pronounced when all four fungi were combined, and then under soil-moisture conditions which were dry until the ear-peeping stage, thence wet until the ripening stage.

* *Helminthosporium M.*=*Curvularia ramosa.*

The experimental data substantiated the writer's contention that field occurrences of wheat foot-rot are not attributable solely to the action of *H. sativum*. In fact, from long association with this problem it is considered that while "take-all" is attributable to the action of a single organism

Control. *Helminthosporium sativum.* *Fusarium culmorum.* *Helminthosporium M.*

Helminthosporium M. +*F. culmorum.* *Helminthosporium M.* +*H. sativum.* *H. sativum* +*F. culmorum.* *Helminthosporium M.* +*H. sativum* +*F. culmorum.*

Effect of Soil Inoculation with root-rotting fungi, singly and in combination, on emergence and growth of wheat.

(*Ophiobolus graminis*) and "purple patch" to a single organism (*Rhizoctonia solani*), the foot-rot disease is in the majority of cases due to the action of a complex of fungi, comprising *Helminthosporium M.*, *H. sativum*, *F. culmorum* and possibly other fungi. It is perhaps significant that in plantings of the basal

parts of foot-rot-affected wheat from the field, more than one type of fungus usually develops in association with *H. sativum.*

The results from field observations concerning effect of rainfall, and those from the controlled soil-moisture tests could not be said to be in entire agreement. In each case, however, there was definite evidence that disturbed water relationships were conducive to disease development. Under dry soil conditions, crown root development and the plants' capacity for root replacement are restricted, and the numbers of micro-organisms in the soil are not as great as when moist conditions prevail, so that inhibition of parasitic activity from saprophytes would be less ; hence disease development would be expected to occur. Under very moist soil conditions, on the other hand, biological antagonism becomes more important owing to increased numbers of micro-organisms which tend to limit the incidence of disease. But the effect of increased moisture on host metabolism must also be considered, and it is known that in soils lacking in humus, especially those containing an appreciable amount of clay—features characteristic of typical wheat country in New South Wales—and subject to excessive rains, circulation of gases is slow and carbon dioxide accumulates with the result that root development is impeded and general metabolism lowered ; hence invasion by root-rotting fungi under excessively moist conditions would also be expected to take place.

The results from the controlled glasshouse experiments clearly indicated that low soil-moisture during the pre-ear-peeping period was the determining factor in disease development, and while many instances of root-rot in commercial stands in this State have come under notice when the occurrences were associated with the dry state of the seed-bed and dry conditions during the winter months, additional surveys are still required to determine the influence of rainfall distribution during the growing period on foot-rot development in adult plants.

EFFECT OF GRAZING AND CUTTING-BACK PLANTS.

Another factor which appeared worthy of investigation from the standpoint of its effect on foot-rot development was the cutting-back of plants already well established in growth. This arose out of field observations by the writer during 1925 and 1926 which showed that healthy, vigorous stands of wheat incurred severe damage from foot-rot and take-all subsequent to being grazed by sheep in July.

The glasshouse tests, involving a dry soil series (30% W.H.C. throughout growth) and a wet soil series (60% W.H.C.), showed that in both cases *Helminthosporium* root-rot in adult wheat was more pronouncedly developed in plants cut back to within 1½ inches of the soil level when 12 inches high, than in those not cut back, *i.e.*, the difference in height between plants in the control non-cut-back pots and those in the control cut-back pots was not as great as in the case of the inoculated series.

An extension of this work in pot culture under outdoor conditions of temperature and rainfall when *Helminthosporium M.*, *H. sativum* and *F. culmorum* were used, singly and in pairs, for the inoculations, again demonstrated that cutting back results in more severe development of the disease. The data on differences showed that the treatment resulted in appreciable stunting and noticeable reduction in yield of dry matter in practically every instance. A most striking feature was the pronounced reduction in root development following cutting back in the inoculated series.

No further study has yet been made of this phenomenon. Whether the new succulent shoots which develop following grazing or cutting back become more heavily attacked at the base by root-rotting fungi which have increased during the early and warmer part of the season is not known. The effect of injury to plants from tramping of sheep or the effect of organic materials deposited would not—in view of the results referred to—appear to be so important as the actual elimination of the top growth. The reduction in root development following cutting back is of particular interest in view of the fact that organic root reserves in some plants are known to vary according to the treatment to which the above-ground plant portions are subjected, and that productivity is affected by these reserves. But much more work is necessary to determine the relationship in wheat of this idea to the concomitant effect of root invasions by parasitic fungi, and the final effect on root and top development.

DISEASE DEVELOPMENT IN FIELD PLOTS.

From several years' work on tests of relative susceptibility of wheat varieties to infection by *H. sativum* in field plots artificially inoculated with this pathogen it became apparent that further work in this connection was useless until more was understood of the factors resonsible for disease development under field conditions. Distribution of inoculum in the rows along with seed at time of planting resulted in pre-emergence blight and seedling blight, but there was never any certainty that the disease would develop in full-grown plants.

Experiments were then undertaken at Cowra Experiment Farm during the three-year period 1931–1933. Control and inoculated plots were employed, and the essential feature of the work was to ascertain whether foot-rot development could be promoted by varying the planting dates and by cutting back the plants to within one inch of the soil level when they were about eight inches high. Fallowed land was used, and the varieties of wheat were of the early, mid-season and late maturing classes, the experimental data on height, tillering, degree of premature ripening, and general ear development being recorded at the late dough stage.

The results of the tests showed quite conclusively that both percentage and severity of *Helminthosporium* root-rot in adult wheat were greater when

varieties—irrespective of maturity class—were planted late (*i.e.* June, July—soil temperatures relatively low), and that cutting back during early growth resulted in intensification of disease development. The most severe manifestations of disease resulted from late planting and cutting back, combined. In cases where plants were cut back twice during early growth, the effects were more severe than where only one treatment was given. The data also indicated that in a season favourable to root-rot development and that when infested land was used for experiments, the addition of *Helminthosporium* inoculum to the soil was of little or no value in so far as the manifestation of disease symptoms in adult plants was concerned. This was probably due to vitiation of inoculum (fungus propagated on oat grains) as a result of rapid multiplication of saprophytes following incorporation with the soil.

Laboratory examination of infected plants from the several plots in each year of test showed that not only *H. sativum* but also *F. culmorum* and other fungi were present on the stem bases. Again, it appeared that injury was due to the action of more than one organism.

In reference to the temperature effect as determined from dates of planting, it should be noted that in seedling tests appreciable damage also resulted from late planting in infested soil when the temperatures were low.

Whether the more severe manifestations of disease in adult plants with late plantings are associated with winter injury to the host before it has become firmly established has yet to be determined. Under commercial cropping conditions in New South Wales, quite variable observations have been made in respect of the effect of time of planting on ultimate foot-rot development. The effect of grazing by sheep—especially late grazing—is now generally accepted by agriculturists in this State as a predisposing factor in the development of foot- and root-rot diseases in wheat, being particularly marked in dry seasons.

An Australian "Winter" Wheat

By

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PHASIC DEVELOPMENT AND YIELD.

It has been suggested that the limits of yield have probably been reached in an Australian bread wheat. It is at least probable that the major factors contributing to yield are present in the best wheats now adapted to the growing season of the Australian wheat belt. Plant breeders have consequently turned their attention rather to adding disease resistance or baking quality to the existing high yielding varieties.

In other parts of the world, wheat breeders are crossing widely different species and genera in the hope of adding fresh characters of value to the genus *Triticum*. The wheat-rye, and especially the Agropyrum-Triticum hybrids of the Russian workers, are classic examples of this new phase of wheat improvement.

A study of the phasic development of the wheat plant under Australian conditions would indicate that, for at least parts of the wheat belt, a definite increase in yield might be expected to result from an extension of the length of the growing season—that is by the earlier sowing of a type of wheat which is best described as an early maturing "winter" wheat. By "winter" wheat is meant a wheat which will "not head out or develop normally if sown in the spring", or a wheat which must experience a well-defined period of low temperatures before normal reproduction can take place.

Since Garner and Allard[4] [5] first showed the importance of length of daylight in stimulating reproduction, numerous other workers have demonstrated that the various stages of development of the wheat plant are initiated by different conditions of light and temperature, which may vary with each variety. Lyssenko[6] [7] [8] has shown that the two most important stages are the "vernalization stage", determined chiefly by temperature, and the "photo-stage", regulated mainly by light.

The principles established by Lyssenko have been applied to Australian wheats by Forster *et al.*,[1] [3] Forster,[2] McMillan[10] and Raw.[11] Vasey[12] has recently pointed out more definitely some local applications of phasic development as influencing Australian wheat breeding, and has suggested that the success of some recent productions has been largely "due to a transference of their later developmental stages to the earlier part of the season".

It is suggested that at present the most profitable line of investigation, at least in breeding for yield in certain of the more favoured wheat districts,

probably lies in an increase in the vegetative phase brought about by earlier sowing. Vasey has pointed out that restriction in the length of this pre-jointing phase, while increasing drought resistance, means a restriction in potential yielding ability under " these climatic conditions ". If the climatic conditions referred to are taken to include the accepted time of planting wheat in these areas, his deductions are correct, but an increase in the vegetative phase resulting from earlier sowing might well be expected to increase both potential yield and drought resistance, " other things being equal ".

By analogy with the yields of the best early and late sown wheat varieties at present in cultivation, it would not be unreasonable to suppose that by sowing such a variety four to six weeks earlier, where possible, than the present early April sown varieties, an average increase in yield of ten to twenty per cent. over the present highest yielding varieties might be anticipated. It is at least common experience that, " other things being equal ", the longer the growing period the higher the yield.

ABSENCE AT PRESENT OF WINTER WHEATS.

The apparent reasons why no effort has previously been made in the direction of evolving wheats for much earlier sowing may be summarized as follows :

1. The former absence of extremely high resistance to leaf and stem rusts precluded possibilities of sowing until late in the autumn, when low temperatures inhibited the growth of rusts which would have occasioned considerable damage to the wheat plant during the autumn. Desirable high yielding, rust resistant varieties are now available for use as parents in breeding such " winter " wheats.

2. Lack of knowledge of the phasic development of plants led to the belief that early sowing and late maturity were associated characters, and since the safe limits of lateness have been reached in existing varieties it was reasonable to suppose that earlier sown wheats would be too late in maturing. It will be pointed out later that " winter " wheats, which may be sown during the summer without risk of heading until the following spring, may also be relatively early maturing.

3. The great majority of plant breeding work has been undertaken in the areas of greater winter rainfall, and there has been no desire to take advantage of the high summer rainfall such as is experienced in the northern wheat belt in New South Wales and Queensland. With an increase in wheat acreage in these summer rainfall areas, the need for early maturing winter wheats has increased. Especially are they needed for sowing on long fallow in these districts.

4. With horse farming, preparation of the seed bed and sowing immediately after harvesting were difficult. Power farming has reduced the harvest period

and speeded up cultivation and sowing operations, thus making very early seeding possible, and reducing the danger of the grain "malting" in the warm seed bed.

5. Oats have chiefly been used for early sowing for winter pasturing, largely because of their better recovery after grazing. A winter wheat would have better recovery power, and greater cold resistance than the existing varieties of wheat; moreover, the subsequent cash grain crop is usually more valuable than is the case with oats.

ADVANTAGES OF A WINTER WHEAT.

These may be summarized as follows:

1. Greater advantage could be taken of the summer precipitation, especially in the more favoured summer rainfall areas, or in those sections where the autumn rainfall is limited and unreliable.

2. A longer growing period may mean increased yield and drought resistance.

3. The dangers of premature break of dormancy and heading during winter months would be obviated.

4. Such wheats would have greater resistance to cold during the preheading stages.

5. Winter wheats would have increased winter pasturing value and better power of recovery after grazing—characters of increasing importance with greater diversification in farming practice.

6. In the cooler districts, such varieties may even assist in supplying summer green feed.

7. Earlier sowing would give more effective weed control, especially on long fallows in summer rainfall areas. The control of wild oats which do not germinate freely until mid-winter, would be a major advantage in the black soil areas.

8. Even on fallowed land, a heavy winter rainfall may be responsible for carrying the available nitrates beyond the reach of the plant. As the nitrogen intake of the wheat plant occurs during its early growth phases, sowing during the early autumn period of active soil nitrification may result in a larger uptake of nitrogen. This may be reflected not only in tillering and yield, but also in the protein content of the grain. In the case of the very late sown or early maturing "strong" wheats, the same condition may be attributable to nitrification and nitrogen-uptake occurring during warmer spring months.

PLACE OF AUSTRALIAN WHEATS.

When Australian wheats are referred to as spring wheats sown in the autumn, it should be understood that there is no clear-cut distinction between winter and spring characters, and that undoubtedly some Australian varieties,

such as for example, Minflor C.6263, Wandilla and Nizam, carry some latent winter factors. The strain of Minflor C.6263, when normally autumn or winter sown, has consistently been a very early maturing wheat, but sown alongside a number of standard varieties, including Dundee, Florence, Pusa, Gular and Ghurka, at Glen Innes on January 21, 1935, it assumed a very prostrate habit and did not ear during that autumn, when the other varieties produced grain normally. The performance of this strain is at least in support of the possibilities of combining the winter character with early maturity under Australian conditions.

In view of the complex parentage of the many diverse Australian wheat varieties, the differences displayed by their phasic reactions are quite expected. Many varieties which inherit in a marked degree the spring tendencies and erect seedling habit of Steinwedel and the Indian parents, have also acquired a susceptibility to winter injury which in certain seasons adversely affects yields. The cold susceptibility of Dundee has had a detrimental effect on the popularity of this variety, while Ford, which at present takes pride of place in acreage in N.S.W., suffered equally with Dundee during the Glen Innes winter of 1937. It is apparently the lack of dormancy of such varieties which is partly responsible for their high yields in seasons when they escape winter injury.

BREEDING WINTER WHEATS.

At Glen Innes, over the past six years, summer sowings have been made of rust resistant hybrids, of parents and of collections of world wheats, as part of a programme of economic wheat breeding. As wheats have been sown over a nine months' period, numerous observations have been made on the differential response of varieties and geographical races of wheat to various periods of planting.

A most important observation was that not all winter wheats are late maturing wheats. This was well exemplified by the behaviour of Early Blackhull, a North American hard red winter wheat. In 1936, Early Blackhull sown as late as mid-June, was three days earlier than Ford at ear emergence, and matured a week ahead of Ford. Sown in August, Early Blackhull remained prostrate and failed to mature during the 1936-37 summer, while the adjacent August sown Ford matured only a few days later than that planted in June. The early seedling habit of Early Blackhull, June sown, was very prostrate, but its habit became semi-erect relatively early in the spring, and the post-jointing stage was relatively short. The growth phases of English winter wheats, such as those of Little Joss described by Forster and Vasey,[3] are obviously much less adapted to breeding winter wheats for Australian conditions than are the wheats related to the " Turkey " wheat group, which are of Russian origin. It is, in passing, of interest to note that Early Blackhull is also highly resistant to flag smut and bunt, moderately resistant to stem rust and, though not

resistant to cold as judged by American winter wheat belt standards, is very highly cold resistant when compared with Australian varieties. Other wheats of similar general type which merit attention locally are Blackhull, Tenmarq, Minturki and Kanred.

Wheats being used in crosses primarily for other purposes, but which are, in addition, valuable as " winter " wheat parents, are Secalotricum, Lin Calel and fixed strains of Hard Federation × Kanred, Hard Federation × Hussar and H.44 × Minhardi.

In the case of English and northern European varieties, of which Little Joss is an example, it is apparent that in February or March sowings local winter temperatures are low enough to allow of fairly normal winter development. That these varieties are extremely late in maturing is due primarily to the inadequate reproductive stimulus provided by local light conditions. In the case of the typical " spring " wheats, as exemplified by the Fifes and related strains, light is again apparently the principal limiting factor. When it is considered that these two types of wheat are grown in latitudes of roughly 40° to 60° as compared with an Australian wheat belt latitude of 30° to 38° (accompanied by rapidly rising spring temperatures), their lack of photo-thermo adaptation and their drought susceptibility is readily understood.

With the recent use, in crossing, of cold susceptible definitely " spring " wheats from Kenya Colony as stem rust resistant parents, and of the Pusa wheats as high baking quality parents, it is most desirable that other parents should be used to compensate for the cold susceptibility of these types. Wheats of Fife origin, though true spring wheats, are, when autumn sown, more prostrate and resistant to cold than most Australian varieties. Although the reproductive and ripening phases of these wheats do not coincide well with the light and heat conditions of the Australian spring and early summer, they have been successfully used as parents of high baking quality in the initial phases of the building up of the great majority of Australian wheats. It is, however, doubtful whether they can supply many additional factors of value, unless it is the rust resistance recently transmitted to wheats of this type from Durum and Emmer wheats.

On the other hand, winter wheats of the Early Blackhull type appear to have been neglected by Australian breeders. Besides being of value as winter parents, such types would assist in adding to Australian varieties cold resistance, recovery after grazing and probably also inherent drought resistance. They are typically rather weak- and willowy-strawed, characters readily corrected by appropriate mating.

Excessive tiller production is a character of many winter wheats, and since high percentage of tiller survival is an important character contributing to drought resistance, it may be that this would be an undesirable character in their use as parents. Wheats of the Turkey type are not, however, as extreme

in their tiller production as are the English winter wheats, and their finer leafed, relatively dormant seedling habit might also assist in water economy, especially in the early phases of growth. Moreover, there is evidence that the winter character may be coupled with moderate stooling and drought resistance by breeding.

Although the breeding of a rust resistant winter wheat for the North-Western Slopes has been an objective at Glen Innes since 1931, it was not previously possible to embark on a satisfactory breeding programme because of the lack of strong-strawed, high yielding, rust resisting parents with which to cross the winter wheats. Now that such lines are available, this project has been commenced. Preliminary work in crossing Tenmarq with Pusa 4 and Dundee, and Minturki with Ford, has indicated that by sowing the early generation hybrids as early as December or January, the spring segregates will seed during the autumn and can be pulled or cut with the mower so late in their development that they do not recover. Winter types are consequently left for harvesting in the following spring, when selection for early maturity may be practised. Selection on the basis of prostrateness of seedling habit may also prove of value in the case of certain crosses, although experience would confirm McKinney's[9] observation that there is no association of recumbence with winter habit, nor with earliness of maturity.

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TECHNICAL NOTES

A WHITE GRUB EPIZOOTIC IN NORTH QUEENSLAND.

The Scarab, *Lepidiota caudata* Blkb., has for some years been a serious pest of pastures near Malanda on the Atherton Tableland. Early in 1937, third stage larvæ were very common, and a heavy beetle flight was anticipated in the following summer. During May, however, field reports indicated that many dead and dying larvæ were present on or near the surface of the soil, and on further examination the epizootic was found to be widespread.

Typical symptoms include necrotic lesions which first appear in the vicinity of the spiracles and ultimately envelop the whole of the body. Sometimes the anal tract is everted shortly before death.

White grubs showing comparable symptoms can be located in most parts of the State, but an epizootic of this type is unusual. Hence, though pathogenic bacteria are of little moment in insect control practice, the phenomenon was investigated, and the purpose of this note is to record some surprising features.

White Grubs showing development of symptoms following inoculation with Staphylococcus.

Though the requirements of pathogenic bacteria vary a great deal, crowded host populations and a humid environment are usually associated with natural insect epizootics. The present outbreak occurred shortly after the driest summer for some years, and first attracted attention in May, when the surface soil was parched. This suggests that current ideas on insect epizootics require some modification.

It is reasonable to suppose that the causal organism in any epizootic among subterranean insects is generally distributed through the soil, the increased

pathogenicity in an outbreak being due to either a more virulent mutant form or environmental conditions which predispose the insect to attack. The latter are difficult to investigate, but the more simple cultural work may be expected to shed some light on the conception of virulence. Isolations were therefore made from the bacterial flora in the body fluids of diseased insects, and four distinctive organisms obtained. These included a staphylococcus, two bacilli and a diplococcus, each of which was cultured successfully on peptone agar, a medium which strangely enough proved more suitable than beef agar. Suspensions of each of these organisms were hypodermically inoculated into healthy white grubs, but only staphylococcus proved consistently fatal, the symptoms corresponding closely with those in field material. Death occurred within 48 hours, and in a much shorter period when the organism had been subcultured for some weeks.

Hypodermic inoculation may be compared with larval injury, but the latter can scarcely be postulated as a basis of an epizootic. As white grubs ingest considerable quantities of soil, infection through the alimentary canal seems the obvious method of attack in the individual larva. Attempts to induce rapid infection through the gut in the laboratory failed completely. Larvæ sprayed with a concentrated suspension of staphylococcus and returned to soil suffered no ill effects within two months. Larvæ kept in soil thoroughly soaked in a virulent suspension also escaped attack for a similar period. The work has been repeated several times on white grubs of various species with precisely the same results.

The experimental data suggest that the necessary predisposing conditions for infection (whatever they may be) on an epizootic scale have not been fulfilled in the experiments. Failure to induce rapidly fatal gut infection can scarcely be explained in this way, and it is possible that in the field the pathogen procures an entry into its host at some vulnerable phase—perhaps at a moult. If infection does take place through the gut, the onset of typical symptoms and death must be very slow.

From the economic point of view, it is interesting to note that the recent natural mortality in the 1937 white grub population should ensure relative freedom of pastures from serious attack for some years on the Atherton Tableland. The insect has a two-year life cycle, and the previous generation was almost wiped out by dry soil conditions in the spring of 1936, which inhibited beetle emergence. Now an epizootic has played havoc with the present generation, and even with ideal weather for the insect in the next few years it should not reach pest proportions for some time.

This note summarises observations by several officers in the Queensland Department of Agriculture who have been interested in the phenomenon.

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EFFECT OF ADDING MILK TO AGAR ON THE PLATE COUNT OF BUTTER.

The increase in bacterial counts obtained by the addition of milk to the standard nutrient agar used in milk examination has been reported and commented upon by various investigators. The enrichment of the standard medium in this manner has been attended by satisfactory results in the examination of butter in this laboratory. The development of *S. lactis* and similar lactic acid streptococci has been found to be quite variable on standard nutrient agar, and as the occurrence of this group in locally manufactured butter has important diagnostic applications, the need for a routine medium which will consistently favour its development has been realized.

In an experiment designed to determine the optimum concentration of milk for routine examination, 12 butter samples were plated on standard nutrient agar containing 0·5%, 1%, 2% and 5% of sterile milk which had been added aseptically. The plates were incubated for five days at 30° C.

An analysis of variance carried out on the results indicated that while the general increase in counts due to the addition of milk was significant, no optimum milk concentration could be proved. Calculating the increase in counts due to the addition of milk as percentages, and obtaining an average over the series of twelve butters, the following figures were secured :

Control. (S.N. Agar.)	Standard nutrient agar +			
	0·5% Milk.	1% Milk.	2% Milk.	5% Milk.
100	122·4	131·9	125·5	133·6

The most suitable concentration of milk appeared to be 1%, as it gave less turbidity than the higher concentrations, and at the same time was apparently well above the minimum concentration necessary to produce significant increases in counts. This concentration has been found to be most suitable for milk also by Hiscox, Hoy, Lomax and Mattick,[1] and Wilson.[2]

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The Australian Institute of Agricultural Science

NEW SOUTH WALES BRANCH.

The fourteenth meeting of the Branch was held on October 8 at Science House. Mr. A. W. S. Moodie, in an address on " The Scientific Principles of Turf Management ", mentioned that the application of science to problems of turf management was of comparatively recent origin. Much valuable work in this connection had been carried out by the United States Golf Association Green Section and the Board of Greenkeeping Research of Great Britain.

It was emphasized that turf culture is a highly specialized form of agriculture, the management of the dense sward of plants of which turf is composed representing a form of very intense culture. Plants existing under such crowded unnatural conditions, and maintained by copious watering and liberal feeding, are sensitive to even slight changes in management and are subject to fungus diseases and insect attack.

The practical application of all the knowledge recently acquired has had amazing results, which can be appreciated by studying the turf on a first class golf green and comparing it with the average home lawn.

Mr. C. J. Magee, who recently visited Fiji in connection with a search for a variety of banana resistant to the bunchy top disease, gave an account of the banana industry in that country. Mr. Magee pointed out that the Fijian banana industry is of interest to Australia not only on account of the recognized high quality of the fruit, but also because two of our most important banana diseases, viz. bunchy top and Cercospora leaf spot, went through their nursery stages there.

The limitation of markets has reduced the industry to only a shadow of its former flourishing condition. The Australian market was at one time the mainstay of the industry, but the high tariff imposed in 1921 by the Commonwealth Government completed the destruction of the industry which shipping troubles and diseases had already threatened. New Zealand and Canada are now the only markets available to Fiji.

The fruit is produced on small holdings by native Fijians, Europeans being engaged at present in the industry only as shipping agents. All the export fruit is grown on Viti Levu, on the upper reaches of the Rewa River, the chief variety being the Veimana, although both the Cavendish and the Gros Michel are in limited cultivation.

A series of slides illustrating the handling of the fruit in Fiji was shown.

The fifteenth meeting of the Branch was held on November 12. Addresses were given by Mr. F. T. Bowman on " Recent Advances in the Study of Protoperiodism " (which will be published as a review article in the March, 1938, issue of this Journal), and Mr. R. D. Wilson on " Serological Methods and Plant Virus Problems " (an abstract of which appears under " Current Notes and News " in this issue).

VICTORIAN BRANCH.

At the combined meeting of the M.U.Ag.Sc. and the A.I.A.S., held on August 13, the speaker was Mr. G. W. Brown, Chairman of the Victorian Marketing Association, and a leading fruit grower. In his subject, " The Market Situation of Australian Apple Export ", Mr. Brown traced the early development of the export trade in fresh fruits between Australia and the United Kingdom, and described the nature of the difficulties which had arisen in recent years. The lecturer then described the co-operative effort between Dominion and English growers which culminated in a conference, in London, of all Empire producers of

apples and pears, and the acceptance of quotas by each Dominion. Mr. Brown regarded this as the best example of co-operative marketing yet seen.

Students' night was held on September 10, when Messrs. R. H. Hayman and K. D. Nicolls addressed the meeting. Mr. Hayman discussed the problems associated with flax, while Mr. Nicolls spoke on the " Relation of pH of Soil to the Growth of Plants ". (Attendance, 36.)

Mr. F. Penman, Assistant Research Chemist, addressed a combined meeting on October 8. His subject was " Potash in Victorian Soils ". Following an outline of the chief methods of expressing the various forms of potash in soil, consideration was given to the potash nutrition of wheat in the northern areas of Victoria, which usually contain considerable quantities of potash in relatively available condition. The considerable loss of potash from the wheat plant during the later stages of growth was illustrated by means of a graph of potash content of a wheat crop at Rutherglen, and by reference to results at Longerenong. The bearing of this potash situation on the general nutrition of the wheat plant was discussed, with special reference to nitrogen and lime.

As replaceable potash, determined by the Hissink Method, has proved useful in recent studies on Victorian soils, figures on this basis for a number of locations in the north were discussed. For southern soils, special attention was given to soils carrying pastures, the response of which to various fertilizers was known from the work of the agrostology section of the Department. These soils were grouped according to their content of replaceable potash into three categories, which are related to the response of the pastures to potash fertilizer. With reference to the western district, the responsive locations all conform to one general type of soil profile development, so that knowledge of the nature of the soil profile coupled with that of the replaceable potash content of the surface soil provides a useful index to potash status. Studies of fixation of potash in western district soils have shown that only the heaviest of them fix potash to an appreciable extent.

Examination of soils from the rate and frequency of irrigation tests on pastures at the State Research Farm, Werribee, has shown that there is considerable loss of potash, in citric acid-soluble replaceable form, from the upper horizons of the more heavily irrigated treatments, only portion of the loss being accountable for by estimation of potash removed in produce. (Attendance, 64.)

On October 22 Dr. Forster, who had recently returned from two years' study abroad, while holding a Commonwealth Fund (New York) Fellowship, gave an address on " Some Aspects of What Overseas Agricultural Scientists are Thinking ". The substance of this address is published as an article in this issue.

Social News.—The annual dinner of the M.U.Ag.Sc. and the A.I.A.S. was held at " The Wattle " on September 22, and was attended by 82 members and friends. The chief guests were Prof. A. Burstall, and Messrs. A. F. Bell, L. R. East, F. Ellis, T. Hartigan, W. J. Lambert, C. McPherson and W. O. Shew.

WESTERN AUSTRALIAN BRANCH.

Agriculturists in Western Australia were fortunate in being able to meet Professor A. E. V. Richardson on the occasion of the visit of representatives of the C.S.I.R. Executive to Western Australia in October. Professor Richardson addressed a meeting of the Branch on October 5, 1937, and dealt with the place of the extension worker in the agricultural industry. In presenting his views, an interesting survey of the field of agriculture was given, and it was shown that the extension worker played a most important part in that field. His main duties involved the placing before the farming community of the results and application of research, and the giving of technical advice on the numerous problems with which the farmer was faced.

While in Western Australia, the visitors toured the agricultural and forest areas. The work in the forests was highly commended, and Professor Richardson expressed his appreciation of the possibilities of further pasture development in the wetter areas of the State, making use of improved pasture species and strains, and liberal fertilizer applications.

At the meeting on August 6, Dr. Samuel gave an address on " Bread Manufacture ". The lecturer dealt with the ingredients used in bread-making, their properties, and the part played in the production of a satisfactory loaf—a bold upstanding loaf with a good texture and a golden brown crust. The lecture was illustrated by a ciné film showing phases of the industry.

QUEENSLAND BRANCH.

A meeting of the Queensland Branch was held on October 8, the subject for discussion being " The Rôle of Green Manuring in Queensland ".

Mr. McKeon surveyed recent experimental work in the coastal areas, and pointed out that the organic matter content of the soil showed marked depletion as one passed north through the State. A variety of green manurial crops have been used, but the biggest obstacles to their general adoption are the uncertainty of economically worthwhile results and the difficulty in altering existing cropping practices. The need for soil improvement to maintain adequate fertility is undisputed, but the best method of effecting the improvement in general agricultural areas still remains to be worked out. Messrs. A. F. Bell and Von Steiglitz summarized green manuring methods in sugar cane areas where cow peas, poona peas and other leguminous crops are extensively used in the preparation of land for plant cane. Various rotations are at present being investigated in which a green manure is grown once in approximately four years. Laboratory experiments on the effects of trash additions to the soil at a rate equivalent to 200 tons green weight per acre increased the moisture equivalent in three different types of soil and also produced substantial increases in the amounts of available plant foods.

Other speakers dealt with specialized features such as green manuring in relation to tobacco leaf quality, the effect of the ploughed-in crop on the soil microflora, and plant indicators of the need for green manuring.

Current Notes and News

AGRICULTURAL SCIENCES CLUB, S.A.

At the August meeting of the Club, which was held on the 26th of that month, a series of short papers and exhibits was provided by members.

Mr. R. L. Crocker, of the Soils Division, C.S.I.R., gave an illustrated account of a journey he had made to Central Australia in company with Dr. C. T. Madigan, of the Adelaide University Geology Department. The object of the expedition, which was in the field from May to July, 1937, was primarily geological, although botanical specimens were collected when opportunity offered, and a series of soil samples was obtained.

Detailed geological investigations were carried out in the Chandler, James and Waterhouse Ranges, to the south of the McDonnell Ranges. The structures here are favourable for oil, and the work was prompted by the interest of the Commonwealth Government. The principal object of the expedition, however, was the investigation of an alunite deposit in the Tarlton Ranges, about 300 miles E.N.E. of Alice Springs. Chance led to the discovery of a large meteorite on Auckita Station and a large meteorite crater with associated meteoric iron on Box Hole Station; these stations are also E.N.E. of Alice Springs, and about 50 miles apart.

Mr. J. K. Taylor described a method for sampling soil monoliths. An older method had been devised by Glinka, in which a block of soil was exposed, coated with plaster of paris and then transported intact to the laboratory. The block was then stood in a bath of paraffin wax, which infiltrated from below into the soil mass. After cooling, the block was sawn down, giving a profile in which the soil texture and cavities were readily seen. The particular method exhibited by Mr. Taylor was a modification of Glinka's method that had been worked out at the C.S.I.R. soil research station at Griffith, N.S.W. In this method the face of a pit was dried with a blow-lamp flame, coated with wax and then with plaster of paris. Monoliths were then sawn, the section lifting out and preserving the texture of the particular soil sampled. These monoliths demonstrated readily the physical characteristics of the soils, and also were useful in indicating their probable behaviour under irrigation or drainage. Monoliths obtained by the above method were demonstrated.

Dr. J. Davidson exhibited a series of lantern slides which illustrated the life history and habits of the gorse-seed weevil (*Apion ulicis*). The slides had been made at Rothamsted some years previously, and were of high quality. The weevil was of interest in that it had been introduced into New Zealand as a possible agent for the biological control of gorse.

Mr. D. B. Adam showed selected pots from a factorial experiment designed to give information on the level of nutrition of the wheat plant on the incidence of take-all. Plants supplied with adequate phosphorus were grown in soil inoculated with *Ophiobolus* ; they were much less affected than plants grown without phosphorus supplement. Nitrogen supplied as sulphate of ammonia gave considerably less protection. The method of inoculation of the fungus was shown to affect incidence of the disease.

IMPRESSIONS OF THE NORTHERN TERRITORY AND THE KIMBERLEYS.

At the meeting of the S.A. Branch of the Institute held on September 28, 1937, Professor J. A. Prescott gave an account of his recent visit to the Kimberley District of Western Australia and to the Northern Territory, during which special attention was paid to the nature and distribution of the soils. More than 100 samples of soils were collected. A Divisional Report by Professor Prescott, dealing with his visit, has been circulated by the C.S.I.R. The following is a summary of the address to the S.A. Branch :

The climate is characterized by sharp seasonal incidence, with 60 inches of rain in Darwin and a season of 6·6 months, to 20 inches of rain at Hall's Creek with a season of 3·0 months' duration.

A very close soil and climatic parallel is afforded by northern Nigeria and by some of the provinces of French West Africa. In West Africa, however, the variability of the seasonal rainfall is much less than that of tropical Australia.

The vegetation associations include " corridor " jungle forest along the coastal rivers, with a sclerophyll forest on laterite affording a tropical parallel to the jarrah bush of Western Australia in areas with more than 50 inches of rain, extensive areas of savannah woodlands in areas with 30 to 50 inches of rain and the more arid monsoonal savannahs and open grasslands in the regions with 20 to 30 inches of rain. The characteristic trees of the region include many like the boabab and the bauhinia which shed their leaves during the dry period. A little known and unexpected plant was a native *Vitis* perfectly adapted to the seasonal character of the rainfall. The cajuput—*Melaleuca leucodendron*—is an important tree in the low-lying sandy areas liable to waterlogging during the wet season.

Grasses are very important, and in the wetter regions grow so rapidly as to have pastoral value for a very brief period. The best pastoral country is in the regions of moderate rainfall.

The soils of the Northern Territory are reputed to be poor, but absence of soil rather than poverty of soil is responsible for this reputation ; large areas of stony tableland and skeletal soils occur and natural erosion is much more vigorous than in southern regions with more gentle rainfall. The country consists, consequently, principally of ranges and flats with stony shallow soils on all undulating areas.

The heavier soils of the Fitzroy, the Victoria River Downs and of the Barkly Tablelands belong to the brown soil group with the grey Riverina soils as the temperate equivalent. The " pindan " or sandy soils of the Kimberleys consist of long, low, parallel ridges well vegetated with a small tree, tall grass savannah. The soils are brown in colour and are probably equivalent to the mallee soils except that they are probably free from salt.

Red-brown earths occur north and south of Katherine, and a good " rendzina " was observed on limestone near Elsey on the Roper River. Very heavy clay soils subject to annual flooding occur between the Adelaide River and the East Alligator River, and probably to the north of the Daly.

Agriculture is based almost exclusively on the cultivation of the peanut, and is centred at the Daly River and at Katherine. There are about thirty farmers in the whole territory, Irrigation for the growing of vegetables is practised at the homesteads on the cattle stations, and for commercial production at four localities. Springs in the gullies of the tablelands give rise to peaty soils which are favoured for this purpose.

Few Australians from the south are engaged in agriculture itself. The farmers are mostly newcomers—a few from Britain, but mainly Russian emigrés from Vladivostok. The Russians are the only ones making real homes for themselves on the Katherine farms. A few farms and market gardens are held by Australian-born Chinese. Aboriginal labour is important both on the cattle stations and on the peanut farms.

The future of agriculture in the territory is dependent on a realization of the limitations imposed by the seasonal character of the rainfall. The annual drought is longer and more severe than anything experienced in the south. The weakness of the present system is the absence of crop rotations and the dependence on the south for most food supplies. Even vegetables are transported by air from Adelaide to Katherine and Darwin.

SOIL WORK IN WESTERN AUSTRALIA.

At the October meeting of the Agricultural Sciences Club of the Waite Research Institute, Mr. G. H. Burvill presented a paper on " Soil Work in Western Australia ", of which the following is a summary.

Since 1928, the Western Australian Department of Agriculture has carried out a large amount of soil survey work, of which the greater part has been in the mallee soil zone on the margins of the wheat belt. Low rainfall (11–15 inches) is characteristic of these areas, and in parts soil salinity has added to the problems of wheat growing. The determination of the salt status of the soils has been a major feature, along with the mapping of the soil types. The three largest surveys, centred respectively at Lake King, Lake Brown and Salmon Gums, totalled nearly one and a quarter million acres. The largest of these (Salmon Gums) embraced 582,000 acres. Its cost was £12,000, or £20 per farm, and the information gathered has been used as a basis for reconstruction of the district so as to utilize the most satisfactory soil types. The cost of the survey is small when it is realized that Government advances to settlers in this district have totalled nearly £750,000, of which about £500,000 is to be written off.

By means of both general and special samplings, much valuable information on the distribution and movement of salts in soils has been obtained. Data from thousands of sampling sites in the main soil types of the Salmon Gums survey reveal that the virgin soils of that area are generally high in salt. From 60 to 90 per cent. of the sites have, to a depth of two feet, more than 0·22 per cent. sodium chloride. Cyclic salt, deposited as

dust and with rain, is thought to be the chief source of these salt accumulations. Rain water analyses over four years show that the accession of salt per acre per annum at Salmon Gums is 27 pounds, and at Merredin 16 pounds. The low leaching power of the rains under virgin conditions is shown by salt profiles, which have maxima from one to three feet from the surface.

At Salmon Gums, important changes in the salt status of the soils follow clearing and cultivation. Sandy surfaced types with sandy clay subsoils (Circle Valley and Scaddan series) undergo a marked leaching, which may reduce the sodium chloride from 0·4 to 0·1 per cent. at a depth of one foot, and from 0·5 to 0·2 per cent. at two feet. Powdery calcareous soils (Beete series) and heavy crabholey soils (Kumarl and Dowak series) develop a very patchy distribution of salt after clearing, and bare sterile salt patches become common on them. These differences in behaviour after clearing emphasize the importance of mapping according to soil type. An experiment at Merredin in tanks has confirmed the effects of a 5-inch sandy layer in increasing the leaching power of low rainfalls under fallow conditions. The efficiency of such a sandy layer in moisture conservation has also been clearly brought out.

Towards the wetter margins of the mallee zone in the Salmon Gums district an excellent example of a structural alkali soil, or " solonetz ", has been found. The Scaddan series has a sandy surface overlying a sandy clay subsoil, the upper part of which is divided into irregular domes up to one foot across and six to nine inches high. A very stunted mallee vegetation association occurs on this soil series.

BLEACHING AND WEATHERING OF WHEAT.

Mr. L. S. Cayzer, Cereal Chemist of the N.S.W. Dept. of Agriculture, in a recent address to agricultural instructors and farm managers, summarized the results of extensive investigations on the effect of bleaching and weathering on wheat. It was found that some varieties, notably Dundee and Baringa, far from being damaged by severe bleaching, were greatly improved in both milling and baking quality, whereas other softer varieties, although improved, showed a much less marked change.

The theory was advanced that the improvement in quality brought about by severe bleaching is due to a change in the degree of maturity of the flour, as Farinograph and Fermentograph tests showed that the increased enzymic activity of the bleached samples was only slight and certainly not sufficient to account for the very marked difference in baking quality of bleached and unbleached hard wheats. The course of flour maturation was illustrated graphically, and it was shown that when flour is either under-matured or over-matured the baking quality is not at its optimum. The change in the maturity brought about by bleaching in the field was claimed to be comparable to the changes incidental to ageing of the flour on storage, or to the changes brought about artificially in the freshly milled flour by heat treatment, or by oxidation with nitrogen trichloride, chlorine and such substances.

With reference to the effect of bleaching on the keeping quality of the flour, Mr. Cayzer said that tests over a period of six months had shown that flour milled from bleached wheat does not tend to deteriorate any more rapidly than that made from unbleached wheat.

SEROLOGICAL METHODS AND PLANT VIRUS PROBLEMS.

At the November meeting of the N.S.W. Branch of the Institute, Mr. R. D. Wilson, M.Sc., M.Sc.Agr., gave an address on " The Application of Serological Methods to Plant Virus Problems ". The following is a summary of the address :

The application of serological methods to the study of plant virus diseases is of comparatively recent origin, the first experiments on the production of antiserum to extracts of plants affected with a virus disease being reported in 1927.

The most important investigations on this subject have been carried out by workers at the Rockefeller Institute, the Boyce Thompson Institute, the University of Chicago, the Rothamsted Experiment Station and by several investigators in Japan and France. In particular, the contributions of K. S. Chester at the Rockefeller Institute during the last three years have added much to our knowledge of plant virus serology.

The anaphylactic, precipitin and complement-fixation techniques have been utilized in studying the serological properties of plant viruses. Of these, the precipitin reaction has been most widely used and appears to be the most useful.

Using the Schultze-Dale modification of the anaphylaxis test, Chester found that healthy plant proteins are highly active anaphylactically, but that tobacco mosaic protein is not. By this method he was able to show that certain lots of chemically purified tobacco mosaic protein contained some healthy plant protein.

In the preparation of antiserum for use in complement-fixation and precipitin tests, the usual procedure is to make intraperitoneal or intravenous injections of juices from virus affected plants into rabbits or other animals. Before injection the juice is often partially purified to remove most of the suspended plant material. The injections are repeated at intervals of a few days until the serum shows a sufficiently high anti-body content. The serum obtained from the animals is then treated with juice of healthy plants of the same species as that from which the juice was obtained for injection. This treatment absorbs the anti-bodies to the healthy plant proteins, and leaves only anti-bodies to the proteins which are present in virus-infected plants but not present in healthy plants.

The antigens used in tests with such absorbed antiserum may be any material in which the virus is present or suspected of being present. Where plant extracts are used, it has been customary to purify them partially by freezing and centrifuging but in the " Field Method " recently described by Chester the plant juice is not subjected to any purification process. The suspended plant plastids and other plant materials are involved in the precipitation, and a reaction is secured in a much shorter time without the labour involved in purifying the plant extracts.

Matsumoto has given details of a microserologic method in which the precipitin reaction was observed microscopically.

Chester found the complement-fixation test to be highly satisfactory with tobacco mosaic and latent mosaic of potato, but negative reactions were obtained with several viruses which gave reactions by the precipitin test.

Several workers have endeavoured to determine whether it is the virus which is the effective antigen in the precipitin test. The available evidence strongly suggests that it is the virus itself which is the antigen.

Although numerous viruses have been shown to be active serologically, there are many which so far have not responded to the serological techniques. There appears to be a correlation between seric activity of virus juices and the ease of mechanical transmissibility, ability to retain infectivity when subjected to dilution, thermal inactivation and longevity *in vitro*.

Serological methods have been utilized in identifying and classifying various virus diseases, and in other phases of plant virus investigations. The application of the " Field Method " of precipitin testing will aid in the rapid identification of many plant virus diseases, both in the field and in the laboratory, and should serve as an aid in roguing and possibly in tuber indexing.

EXTENSION SERVICES IN AGRICULTURE.

In the course of a recent address, Dr. A. R. Callaghan, Principal of Roseworthy Agricultural College, stated that in Australia the average wheat yield was 12·17 bushels per acre for the period 1921–25, and that it was still about the same level in 1931–34,

namely 12·26 bushels per acre. While a 50% increase in yield may not be possible on the present area devoted to wheat, it seems highly probable that if all the available knowledge in agriculture were more systematically and more universally disseminated, then a 25% increase in efficiency, which would be measured by an equal increase in yield, may be achieved.

The point is, are we over-emphasizing research to the extreme neglect of our extension services ? It seems that we are, for the gap between the proved knowledge that research has made available, as applied by the really first class up-to-date farmer, and that known and applied by the average, and especially the below-average farmer, is enormous.

Research work must, by all means, go on, for it represents the foundation of lasting progress, but out of fairness to the nation and the rural producer, the results of that research should not lie idle waiting for financial aid, proper organization and energy to take it to every farmer in the land.

AWARD OF DOCTORATE IN SCIENCE.

The award by Adelaide University of the D.Sc. degree to Mr. H. C. Trumble this month is the first occasion on which the doctorate in pure science has been conferred on an Australian graduate in agricultural science. The honour comes as a result of several years' distinguished work on the relationships between environmental factors and herbage plants in South Australia. The main aspects of the study were : agricultural climatology, mineral and water requirements of herbage plants in relation to drought resistance, agro-botanical investigations of cultivated pasture species and the associated growth of herbage plants. Most of this work has been published in a series of 25 research papers.

Dr. Trumble is the agronomist to the Waite Research Institute, to which position he was appointed in 1927 after having held the post of assistant agronomist from the time the Waite Institute was established in 1925. He received his university education at Melbourne, securing first class honours and first place in Agriculture I, II and III, and graduating B.Agr.Sc. with first class honours in two schools at the final honours examination in 1925, and winning the Gyles Turner Scholarship. Later he was admitted to the M.Agr.Sc. degree.

In 1928–29 he studied at the Welsh Plant Breeding Station, Aberystwyth, and the Rowett Research Institute, Aberdeen, subsequently investigating pastures and wool production in Palestine, Algeria and Morocco on behalf of the Empire Marketing Board.

Dr. Trumble is a son of Mr. Hugh Trumble, the famous international cricketer, and has himself achieved distinction as an A grade player in South Australia.

GRANTS AND BEQUESTS, WAITE INSTITUTE.

The Government of South Australia recently passed a bill providing for the continuance of the present annual grant of £15,000 for agricultural research at the Waite Institute for a further period of seven years.

The Council of the University of Adelaide has accepted an offer of Mr. James Waite, son of the late Mr. Peter Waite, and at present living in England, to donate a sum of £100 per annum to assist in the investigation of soil erosion problems.

The Ranson Mortlock Laboratory for research on soil erosion and pasture regeneration is nearing completion, and is expected to be ready for occupation at the end of the current year.

SOIL EROSION INVESTIGATIONS, S.A.

The preliminary experimental centre for soil erosion investigations was established at Pallamana, S.A., because of its location in an exceptionally dry belt, only 50 miles from

Adelaide. Despite an exceptionally favourable season over almost the entire State, the total rainfall at Pallamana from January 1 to October 31 has been only 9·13 inches, with 6·21 inches received within an effective rainfall season of May–September inclusive. On this rainfall it has been possible to establish and grow with a good degree of success a comprehensive range of indigenous and exotic herbage plants, including a large number of saltbushes, bluebushes and introduced ephemeral species.

To supplement the field investigations on soil erosion, a selected range of 54 herbage species is being grown in pot cultures.

FIRST CHAIR OF ENTOMOLOGY IN AUSTRALIA.

It has been announced that the Council of Adelaide University has appointed Dr. James Davidson as Professor of Entomology, the appointment dating from January 1, 1938. This marks the establishment of the first Chair of Entomology in any Australian University.

Dr. Davidson is Head of the Department of Entomology at the Waite Research Institute, having been appointed to that post in 1928. He is a graduate (D.Sc.) of Liverpool University, and prior to coming to Australia conducted research at Rothamsted, the Royal Biological Institute at Dahlem, Germany, the Royal Institute for Agricultural Entomology at Florence, the Royal School of Agriculture, Portici, and the National Institute of Agriculture in France. He is the author of numerous papers on entomological subjects. During the war, Dr. Davidson's services were utilized in connection with sanitation and the control of insects associated with the spread of human diseases.

Book Reviews

Methods in Plant Physiology, by W. E. Loomis, Ph.D., and C. A. Shull, Ph.D. (Pp. xviii+472, with 94 figures and 12 tables; appendix with 33 tables. London: McGraw-Hill Publishing Co., Ltd. 1937. Price, 25/–.)

This book is in two parts. The first describes a large series of experiments ranging from demonstrations for elementary students to " quantitative experiments in plant physiology requiring research apparatus and technique ". The second is devoted to details of analytical and physico-chemical methods, and also concludes with a chapter on statistics as applied to experimental biology; the second part is thus entirely of an advanced nature. A collection of useful tables is included in an appendix.

The first part is a much better and more valuable presentation than the second. The experiments for the most part are very suitable for class work, such as in second and third year botany courses in Australian universities. It might be suggested that some elementary statistics could be included with certain of these experiments; even in simple experiments, class data could be pooled and the significance of the differences between means calculated. Students would thus early be brought to appreciate the phenomena of variability in replicated data, and of significant and insignificant differences.

Coming to the second part, one realizes that the book has attempted to cover too large a field. This part might be used for providing exercises in quantitative manipulation, but it is questionable whether it is complete enough to be a reliable guide even for " beginning research workers in plant physiology ". The research worker requires fuller knowledge of the pitfalls inherent in difficult analytical methods, and of alternative procedures, than given in this part. Thus no mention is made of the methods of estimating nitrogen

compounds in fresh material, nor of the superiority of such methods over those using preserved material. The chloroplatinate method of estimating potassium is given, rather than the much more convenient one of precipitation as cobaltinitrite and subsequent estimation as perchlorate. The Hagedorn-Jensen method for sugar estimation is not given, although this is probably the most reliable and widely used. Only a precipitation method is given for phosphorus, although colorimetric methods (e.g. that of Zinzadzé) are in most cases more convenient and sufficiently accurate for biological work.

The value of the chapter on statistics would have been much increased had some account of analysis of variance been included.

A. H. K. PETRIE.

The Feeding of Crops and Stock, by Sir A. D. Hall, K.C.B., F.R.S. (Second Edition, in three parts. 1937. London : John Murray. Price, 6/– net per vol.)

(Part 1. The Plant. Pp. ix+120, with 18 figures and 9 tables.)

(Part 2. Soils and Fertilisers. Pp. ix+122, with 9 figures and 5 tables.)

(Part 3. The Nutrition of Animals and Man. Pp. xi+108, with 5 figures and 6 tables.)

Part 1. The first of the three small volumes deals in simple language with the elements of plant physiology and structure. No previous knowledge of the subject is necessary, no formulæ embarrassing to those without a knowledge of chemistry, and no unusual biological terms are unnecessarily used. This is a useful book for the school student entering on a course of botany, and can be easily read by those who, not desiring to make a searching study of the subject, are yet interested in easily obtaining a working knowledge of the plant forms and physiological processes with which they come in daily contact in the garden. It contains many practical hints and illustrates many points with easily conducted experiments which give an added zest to the acquisition of knowledge.

Part 2. Modern textbooks on pedology, which is tending more and more into the realms of colloid chemistry, and on soil physics with its advanced mathematical considerations, have no practical appeal to the layman or the agriculturist. This book, however, whilst written for the English agriculturist and outlining many practices that are related to the climatic and seasonal conditions of England, contains much of interest and value that can readily be transposed to Australian humid conditions by the thinking farmer and gardener. Sections dealing with the water relationships of soils, the microorganic life of soils particularly in its rôle of supplying plant life through various agencies with nitrogen, fertilizers and manures, and a practical chapter on the improvement of soils by liming and the building-up of the soil organic matter, are presented in a useful and practical manner.

Part 3. A straightforward and clear exposition is made of the scientific principles underlying the practice of rationing farm animals. The scientific feeding of farm animals is an intricate procedure, being based on the chemical composition of the materials available, and it is therefore necessary that the practical husbandman should be able to grip the essentials of ration formulation from clear and concise methods of procedure. A chapter is devoted to human dietaries, which includes some useful hints on the selection of foods, the best sources and the essential nature of the group of vitamin substances. The author wisely adds that faddism is a nutritional disease easily contracted, and sounds a warning against it.

N. H. PARBERY.

Potash Deficiency Symptoms, by Prof. O. Eckstein, Dr. A. Bruno and Dr. J. W. Turrentine.

(Pp. 235, with 54 coloured plates and 41 figures. Verlagsgesellschaft für Ackerbau, Berlin, S.W.11. RM 5.70. Australian orders through Pacific Potash Limited, Sydney. Price, 12/6.)

Starting from the fact that potassium is one of the essential elements concerned with plant metabolism, and working from some of the classical studies on mineral deficiency symptoms, such as those of Wallace at Long Ashton, Lagatu and Maume in France, Weigert in Germany and Hoffer in the U.S.A., to mention but a few, the joint authors of this interesting volume have produced something which combines the advantages of an anthology of the subject with those of a new contribution offering some original aspects of the work.

Pride of place might well be given to the coloured plates which take up nearly half of the book. Although the colour might not be as good as some that has come from the presses of Germany, the colour differences are well established and there is never any doubt about the particular point which a given plate sets out to illustrate. There are 54 plates dealing with 45 different crops, only two or three of which are unknown commercially in the Commonwealth.

The text is published in full in English, French and German, and even the captions to the excellent micro- and ordinary photographs which illustrate it follow this system. Throughout the text, too, references are given to a profuse bibliography (there are 209 references) which is included.

The first part of the book deals with the general symptoms of potash deficiency as they affect the leaf, root, blossom and fruit, general appearance and the inner structure of the main crop plants. The secondary effects, such as the influence of a deficiency on susceptibility to diseases, pests and climatic factors, are studied as well as the effects on the market value of crops. There is also a short but interesting section on the pathology of potash deficiency.

The second part of the book is specific, and includes, with the coloured plates already mentioned, articles dealing with maize and other cereals by Dr. Hoffer, of Washington, U.S.A., with fruit trees by G. A. Cowie, M.A., B.Sc., and with vines.

Generally it can be stated that whilst the book fully maintains its validity as a scientific work of reference, it also possesses, especially in its illustrations, considerable value for the commercial grower. Mainly, however, its value lies in its utility to the extension worker for diagnostic work in the field.

G. DE VAHL DAVIS.

Agricultural Prices, by F. L. Thomsen, Ph.D.

(Pp. x+471, with 110 figures and 10 tables. First edition. London: McGraw-Hill Publishing Coy. Ltd. 1936. Price, 24/-.)

The book is a thoughtful acquisition to the literature of rural economics, designed to cover the economic principles governing price fluctuations of primary produce.

Economic theory, especially when it comes to the elucidation of the guiding principles of price evaluation, is a subject that may well baffle the lucidity and stylish loquaciousness of even the most fluent exponents of English. While Professor Thomsen deals with his subject in a logical, straightforward manner, ease and grace of expression are not strong features of his book. He, of course, is not alone in this regard, for many technical works

lack finesse in this respect ; consequently they are apt to become text books to the student in the heaviest sense of the term. There is little doubt that, in the case of the book under review, the amount of statistical technique and the number of technical considerations which have, of necessity, been included, have made the literary task of the author difficult. The tendency to deal with local American prices and trends, detracts from the direct use of the book for general reading in Australia. In fact the whole basis of the publication centres round local price levels, and examples given are almost invariably parochial. With our small population in Australia and our economic dependence on export markets, a study of agricultural prices involves a study of world supply and demand rather than any local operation of these factors. For this reason, Professor Thomsen's book is only likely to appeal to the academician.

Technically the book forms a very helpful basis, and is worthy of study by all those interested in the principles of price-making forces. To the ordinary student who has no particular leanings or desires for specialization in agricultural economics, the work is too technical, but as the author explains in the preface, an attempt is made to compromise between the requirements of ordinary students and those of the advanced student who is specializing in the subject. In the hands of a discriminating instructor, it might be made to serve the first purpose and be used for classroom study ; for the advanced student it is certainly worthy of careful consideration.

ALLAN R. CALLAGHAN.

Personal Notes

NEW SOUTH WALES.

The second annual conference of teachers of agricultural science was held at the University School of Agriculture on August 31. The Headmaster of Hurlstone High School (Mr. Longmuir) occupied the chair. The Director of Education and the Chief Inspector of Schools were present, and there was an attendance of 17 graduates, as well as other teachers. Mr. P. Hindmarsh, Headmaster of Yanco High School, was elected president for the ensuing year.

Professor Alan Treloar, University of Minnesota, recently returned to Minneapolis from sabbatical leave at the Johns Hopkins University. His laboratories have been transferred from the Botany Department to the Medical School, where the Department of Biostatistics is now established.

Dr. J. G. Churchward delivered a popular lecture to the Royal Society of N.S.W. in October, the subject being " Genetics and Problems of Human Subsistence ".

Four glasshouses are now in operation for the cereal investigation work conducted at Sydney University by Dr. W. L. Waterhouse and others. Three glasshouses served the purpose for several years, but the fourth was only recently completed.

Mr. F. T. Bowman, late Ben Fuller Scholar, recently returned from U.S.A. and England, after an absence of over two years. After securing his M.S. degree at the University of California, he continued his studies at Michigan State College. Later he travelled extensively, visiting all the well known centres of horticultural research and principal fruit districts of U.S.A. and Canada, and whilst in England spent some time at East Maling and Long Ashton.

Mr. O. Perkman, Farrer Research Scholar, in a report to the Farrer Trust, has outlined some interesting new methods of approach to quantitative inheritance problems. Field work, designed to test out the methods, is now in progress.

Mr. J. A. Wright, Assistant Entomologist of the Department, has been transferred to Grafton, N.S.W.

Mr. B. Doman has been appointed Instructor in Agriculture at Hawkesbury Agricultural College, Mr. T. E. Kitamura having replaced him as Assistant Plant Breeder at Temora Experiment Farm.

Miss Joan Woodhill has been appointed to the dietetic staff of Royal Prince Alfred Hospital.

SOUTH AUSTRALIA.

Professor A. E. V. Richardson recently visited Western Australia in company with the Chairman of the Council for Scientific and Industrial Research, Sir George Julius, to enquire into the position of agricultural research in that State and to encourage a closer degree of co-operation in research between the University, the Department of Agriculture and the C.S.I.R.

Dr. H. O. Askew, of the Cawthron Institute, Nelson, New Zealand, who is well known for his work on cobalt in relation to bush sickness disease, recently spent a period of three weeks at the Waite Institute.

Mr. A. B. Beck, of the Western Australian Department of Agriculture, spent several days at the Waite Institute in September in connection with recent work on the determination of soil colour.

Mr. A. B. Cashmore, of the Division of Plant Industry, Canberra, visited Adelaide at the end of September in connection with the investigations by the C.S.I.R. of Cape Tulip.

Mr. F. Penman, of the Chemistry Division, Victorian Department of Agriculture, spent a week at the Waite Institute in October.

Dr. L. I. Grange, Director of the Soil Survey Division, Department of Scientific and Industrial Research, New Zealand, while on a recent visit to Australia, spent two days at the Waite Institute and a further two days with the Soils Division field party at Mildura.

Mr. G. H. Holford, B.Sc., of New Zealand, visited the Waite Institute in October on his way back from the World Grassland Congress at Aberystwyth.

VICTORIA.

Mr. W. J. B. McDonald has been appointed to the position of Senior Plant Investigation Officer of the State Department of Agriculture. Other appointments include Mr. J. A. Morrow, Manager, Experiment Farm, Rutherglen, Mr. R. H. N. Trembath, Dairy Technologist, and Mr. M. Rothberg, Plant Pathologist.

Mr. Trembath has returned from New Zealand, where he was sent by the Victorian State Department to study the work at the Massey Research Institute, in view of the establishment at Werribee of the School of Dairy Technology.

Mr. J. P. Ryland resigned recently from the Department of Agriculture to take up a position with Asnett Airways Ltd.

Recent visitors to Melbourne included Dr. G. L. Sutton, Director of Agriculture; Mr. G. K. Baron-Hay, Superintendent of Dairying; and G. L. Throssell, Agricultural Instructor—all of Western Australia.

OTHER STATES.

Mr. F. E. Ward, until recently Director of Agriculture in Tasmania, has severed his connection with the Department. Members of staff assembled on August 31 to extend their best wishes, and a presentation was made by Mr. F. W. Hicks on behalf of the whole staff.

Mr. J. M. Allan has resigned from the C.S.I.R. to accept the position of Tobacco Research Officer in the D.S.I.R. of New Zealand.